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AGE-LIMITS AND WORKING LIFE

THE National Advisory Committee on the Employment of Older Men and Women was appointed in March 1952, "to advise and assist the Minister of Labour and National Service in promoting the employment of older men and women". Under the chairmanship of Mr. H. Watkinson, Parliamentary Secretary to the Ministry of Labour and National Service, the Committee has taken this as an instruction to consider what conditions or circumstances hinder the employment of older persons and what are most likely to help. Its aim is to suggest the general lines on which the Government and public and private bodies may work together to enable and encourage men and women in all kinds of employment to use their skills and experience to a greater age, with benefit both to their own well-being and to the national economy.

The Committee's first report*, which has just been issued, shows that it is fully alive to the two main trends in Great Britain which give the employment of older men and women its present national importance—the changing age-structure of the population and the greater expectancy of life—and to the repercussions on personal life and on the national economy which are involved. Both considerations are kept in mind throughout this report; but, although since the Committee was appointed there has been a certain amount of piecemeal action to encourage the elderly to remain longer at work—some, but not all, of which is mentioned in the report—the Committee is wise in this first report to attempt to set forth the main considerations which require general discussion. It is convinced that the principal barrier to the extended employment of older persons lies in traditional attitudes of mind, which only a clearer understanding of the issues is likely to change.

The able statement of the national problem, which embraces consideration of economic and financial aspects beyond the scope of the Watkinson Committee and coming within the terms of reference of the Committee appointed by the Chancellor of the Exchequer "to review such problems in relation to provision for old age", with which Committee the Watkinson Committee expects to work in close co-operation, is an excellent contribution to that end. Its analysis of the changing age-structure and of the implications of working capacity in a longer life supplements admirably the lecture which Sir Frederic Bartlett gave two years ago (see *Nature*, 171, 623; 1953), and the Committee's brief remarks on present and future man-power needs have since received strong support in an address which Sir Godfrey Ince, Permanent Secretary to the Ministry of Labour and National Service, delivered to the Manchester Statistical Society on November 11. The Committee points out that, whereas in 1911 one in fifteen of the population of Great Britain was a man of sixty-five and more or a woman of sixty and more, in 1951 the proportion had doubled, and in 1977 it is estimated

* National Advisory Committee on the Employment of Older Men and Women. First Report. Pp. 62. (Cmd. 8963.) (London: H.M. Stationery Office, 1953.) 2s. net.

as likely to be nearly three in fifteen. Of the 1951 total, two million were men aged 65–69 inclusive, or women aged 60–64. Moreover, the proportion of older people in the working population is also rising. Between 1952 and 1962 the population between the ages of twenty and forty is expected to decrease by about 7 per cent, and that between 50 and 60 to increase by about 17 per cent. By 1962, men aged 18–40 inclusive will be nearly 300,000 fewer than in 1952, and since on men in this age group the armed forces, the police, the fire services and all the occupations for which full vigour and activity are essential must have first claim, other occupations must employ a smaller proportion of them.

On this ground alone it is essential for all employers to make the fullest use of the abilities of older people below pensionable age, and also to employ to the best advantage those beyond pensionable age who are both able and willing to continue at work. Economic considerations enforce the argument. The increase in the proportion of older persons in the population means an increase in the amount of current production required for their maintenance; and the effect on standards of living may be greater should this increase not be offset both by advances in productivity and technical development and by the fullest possible utilization of the services of those able and willing to continue to be productive. No reliable estimate is as yet available of the numbers in Great Britain who might be available if they had the opportunity: at present some 400,000 men out of 850,000 in the 65–69 age group and 250,000 out of 1,250,000 in the over-70 age group are continuing at work, and the Ministry of Pensions and National Insurance is conducting a comprehensive inquiry on the Committee's behalf into the reasons influencing the individual's decision to retire or not; this should assist later in arriving at a reasonable approximation.

The Committee recognizes the need for more research into the process of ageing, and into the differing skills and abilities demanded by particular occupations; but its report adds little to what Sir Frederic Bartlett said on this point. Its argument, however, is strongly supported by evidence provided in the latest report from the Chief Inspector of Factories, in which Sir George Barnett emphasized that while the consequences of accidents to older people tend to be more serious, they do not appear to be more prone to accidents. Many are apparently able to exercise in industry the skill acquired in a life-time unaffected by advancing years. Here, again, more precise information is required before positive conclusions can be reached.

It is the Committee's observation that the encouragement of the employment of older people is a present as well as a long-term need which was most strongly endorsed by Sir Godfrey Ince. If it is Government policy to maintain a high and stable level of employment for all who want to work and are fit to do so, the Committee is convinced there should be no age limit. Limitation of employment opportunities for older people who want to work is not a tolerable permanent solution for unemployment either from a human or an economic point of view. From the short-term point of view Sir Godfrey shows that it may be disastrous.

Assuming during the next ten years a decline of only six per cent in the working population aged between twenty and forty, and an increase of 20 per cent in those aged between fifty and sixty, Sir Godfrey pointed out that the small rise in the total working population expected over the next eight years would by no means match the necessary rate of increase in production. Analysis of the four main tasks now before Great Britain, he said, shows that no immediate substantial reduction can be forecast in the demands of the defence programme: we are unlikely, therefore, to have additional man-power available to expand the capital investment programme and increase the export of engineering products. The second task is the maintenance of exports at an increasingly high level, the third to maintain home capital expenditure at a much higher level than at present and the fourth to produce sufficient consumer goods to keep up the country's standard of living.

These formidable and essential tasks can only be carried out, said Sir Godfrey, apart from some unforeseen change in the general economic situation, by increasing production and particularly by the more efficient use of man-power. Apart from the modernization, improvement and extension of plant, machinery and mechanical power, this will involve the distribution of man-power so that the maximum number of workers are in the right jobs, in the right districts at the right time, more careful training of recruits and existing workers and the establishment of good human relationships in industry. Even so, it is probable that the Armed Forces will have considerable difficulty in recruiting the man-power they need.

The corollary of Sir Godfrey Ince's address is clear: not merely must there be more mobility of labour and the general abandonment of restrictive practices and national habits on the part of industry and business, including the trade unions; there must also be much more flexibility and fresh thinking about retirement, production and employment generally. A new attitude may be required in which the approach is expressed not by 'no men over forty need apply', but rather 'no men under forty need apply'. There are manifestly jobs in industry and commerce in the broadest sense in which the employment of fit men under forty is a disservice to the State.

The Watkinson Committee's observations on engagement and retirement policy, on professional, managerial and executive employment, and on pension schemes, and its tentative recommendations should be considered in the light of such a change of outlook. The Committee insists that the test for engagement should be capacity and not age, and urges that retirement policy should be such that all men and women employed in industry, commerce, the professions and elsewhere, who can give effective service, either in their normal work or in any alternative work which their employers can make available, should be given the opportunity, without regard to age, to continue at work if they so wish. The main difficulties in

giving effect to these principles are found among the professional, managerial and executive classes; but it is here that the Committee believes that unnecessary waste of ability, qualifications and experience is most likely. Moreover, the shortening of the span of working life of the professional classes and certain others in the higher ranges of employment in this century, due to the lengthening of professional training and to earlier retirement on pension, represents a real loss of public and private investment.

The Committee does not underrate the difficulties, but it rightly urges that there should be more flexibility in regard to salary scales, promotion systems and superannuation schemes. The difficulties are a challenge to personnel management which some organizations have already met. What is required is a fresh approach to the question of the retiring age, which may avoid invidious decisions, and still more a greater readiness to make exceptions to it where desirable—and these exceptions should be frequent. Moreover, since pension schemes have a greater influence on the opportunities for employment among the professional and executive class than elsewhere, the modification of such schemes is a matter which concerns not merely professional workers and their own associations as well as their employers, whether industry, the Government or the universities or other bodies, but also the insurance companies with which pension schemes may be arranged. If insurance companies undertaking such business made a common fund and invited those concerns which carry their own funds to join and agree on two or three alternative forms of superannuation contract as standard, it would be easier to provide the flexibility desirable. Moreover, there would be the further important advantage that by enabling a policy holder to move from one concern to another without wasting his own or the employers' contributions, not only would it be easier to place the elderly worker in a suitable post but also throughout his career mobility would be encouraged, to the great advantage of the country as a whole.

There is need both for more information and for more thought on all these matters, as the Committee recognizes. Reference is made to some examples of changes in practice in the recruitment of older workers and in retirement policy, both in industry and in government and local government service. The Minister of Health has since pointed out that between January 1, 1952, and July 1, 1953, the number of permanent Civil servants over sixty years of age increased from 18,781 to 29,208, although there has been a simultaneous decrease of 25,460 in the size of the Civil Service. The Life Offices Association has since issued a statement indicating three ways of designing pension schemes which should eliminate employers' objections, on superannuation grounds, to employing older men. In the University of Oxford, motions to raise the retiring age of all teaching and administrative staff were approved by Congregation on November 3, and on the same day a debate at a meeting of the Senate of the University of Cambridge on a report from the Council on the question of retirement indicated that, while there were diverse views on the question of retiring age, the importance of making greater use of the services of retired officers or teachers was fully appreciated.

The Watkinson Committee deprecates any attempt to move too fast. This first report is intended rather to provoke discussion and to stimulate thought about the various difficulties which questions of promotion and pension schemes present; and to encourage the initiation of further inquiries into fitness and capacity for work at later ages, into the productivity of older workers in comparison with that of younger workers on various types of work, into absenteeism and time-keeping and accident-rates, into the desirability of change of occupation—perhaps with re-training in middle or later life—for men and women employed in certain jobs which may be less suitable for older workers, and into the possibility of minor adjustments in methods and conditions of work and in the design of machinery, which should be advantageous to all, but particularly to the older workers. Some such inquiries the Committee itself proposes to institute, though it will need the co-operation of research bodies and of industry. Meanwhile, this preliminary review should encourage the introduction of further experimental schemes in business and industry, and the careful discussion of the whole subject by employers, trade unions, professional associations and others concerned, above all in the light of the implication of Sir Godfrey Ince's address that we can no longer afford to assign able-bodied men to light jobs which could be performed quite as well by men past their prime.

Where the scientist and technologist are concerned, the demographic argument is strongly reinforced by the existing shortage of scientific manpower. Although the Advisory Council on Scientific Policy in its last annual report stressed the need for greater use of scientists and technologists in industry, and this has been repeatedly urged in diverse quarters and in discussions on higher technological education, no further appreciation of the situation as a whole has appeared since the report of Prof. S. Zuckerman's Standing Committee on Scientific Manpower was submitted by the Advisory Council as its own fifth report. No indication has been given regarding any action on the Zuckerman Committee's suggestions, though the position as regards science teachers appears to have deteriorated. A Productivity Team's report on the heavy chemical industry, which indicated that the ratio of technicians to operatives on the pay-roll is one to six in the United States compared with one to sixteen in Great Britain, tends to support the general impression that, on the whole, British industry does not make anything like sufficient use of trained scientific and technical man-power. Moreover, Sir Ewart Smith's outburst at the annual conference of the British Institute of Management carried the implication that not only is industry using too few highly trained engineering technologists, but also that we are not using as wisely as we might the scientific and technical man-power at our disposal.

The most efficient use of scientific man-power was considered eight years ago by the Barlow Committee on scientific staff, but its recommendations have lost

none of their force in the interval, either in Government departments, in industry or in the universities. The wise use of man-power is above all a matter for management, and it is on management that the major share of responsibility must fall for the adjustments which will ease the strain on our limited resources of man-power as the demographic trends have full effect. Of others also, in the trade unions and in professional associations, a new outlook will be demanded and a readiness to shed obsolete practices and old habits and ideas: the task is not simply one of finding and training men of the requisite ability as managers; but wise management can do something to assist those changes and processes of adjustment. The Watkinson's Committee report is a timely reminder that some hard and constructive thinking is required fairly generally in the professions, in industry, in Government departments and public corporations and in the universities; the report is likewise a useful contribution to the task of education. Last, but not least, retirement policy and the effective use of the older scientist and technologist are essential features in any adequate policy for scientific and technical man-power, of which the expansion of higher technological education and the supply of science teachers are only special aspects, though no less essential.

THE MECHANISMS OF ORGANIC REACTIONS

Structure and Mechanism in Organic Chemistry
By Prof. C. K. Ingold. (The George Fisher Baker Non-Resident Lectureship in Chemistry at Cornell University.) Pp. ix+828. (London: G. Bell and Sons, Ltd., 1953.) 77*s*. 6*d*. net.

THOUGH each monograph written by the holder of a George Fisher Baker Non-Resident Lectureship in Chemistry at Cornell University is an eagerly awaited scientific publication, Prof. C. K. Ingold's volume arouses special interest, since it is a large and fully referenced treatise which gives the first really comprehensive account of all the work with which he and his colleagues have been concerned during the past thirty years.

While Prof. Ingold makes full use of the modern contributions of wave mechanics to valency theory, he clearly shows how present theoretical conceptions are the rational outcome of a century of active research and speculation, and not just qualitative applications of approximate mathematics of recent origin. Thus, typically, when discussing aromatic structure, he points out that what are now called 'observed mesomeric energies' themselves involve interpretative factors of an arbitrary nature. Again, in discussing theories of chemical reactivity, he stresses the view that thermodynamic factors have no essential concern with reaction mechanism, but that it is essential to know, from experimental work, the complete stereochemistry of each successive phase of any reaction process.

The first four chapters deal with molecular structure and with molecular interactions. The treatment is familiar and rational to those who still believe that one of the main properties of valency electrons is that they do have a negative electrical charge and not merely mathematical wave-functions. Welcome stress is given to knowledge of the electrical polarizability of organic molecules. Unfortunately the theory of strong electrolytes gets no mention here, for its applications, particularly in connexion with 'salt effects', are often invoked later in critical discussions of reaction velocities.

There then follows an excellent account of aromatic substitution which, with historically complete references, develops up to 1950 the interwoven electrical polarization and electrical polarizability theories which were the greatest achievements of the British organic chemists of the 1920's. A section dealing with *ortho*/*para* ratios is particularly welcome, since here old facts and modern speculations are often at variance.

Aliphatic substitution processes, elimination reactions and molecular rearrangements of various types receive in all about four hundred pages of detailed discussion. The substantiation of the contrasted unimolecular and bimolecular types of heterolytic organic reactions is, of course, the main achievement of the school of British chemists at University College, London, and hitherto it has been very difficult for any outsider to comprehend the import of each item of experimental evidence. Now that the subject can be judged as a whole, the vital importance of reaction velocity measurements can be realized. Often it is seen that the exact magnitudes of reaction velocities are of as much importance in deciding upon a reaction mechanism as are reaction orders, or the accelerating or retarding effects of substituents.

Many topics which have been, and some which still are, controversial receive discussion in these chapters; but so masterly is the logical development of the argument that it is difficult for even a critical reader to recall much of the divergent speculation of past days, or the cogent experimental evidence upon which it had been based. There are, however, significant contributions to this field of chemistry, originating outside London, which receive little or no discussion. Hammett's empirical equations relating chemical reactivity to chemical structure, and the use of 'competition factors' in connexion with the second, fast, stage of unimolecular substitution processes, are instances which I have noted. Some, but not all, of these omissions may be deliberate. For example, 'hyperconjugation' is rather pointedly treated as a second-order influence upon chemical reactivity. When reading these chapters of the finished book one can visualize its origin, with the meticulous British advocate lecturer facing his American audience and stifling minor criticisms by his sheer mass of factual information. Overwhelming evidence has been given to show that the full electronic theory of chemical reactivity, as developed from the time of Lapworth, is both more adequate and more applicable to experiment than the restricted American resonance theory.

Unfortunately, the last hundred pages of this book, dealing with acidity, catalysed reactions, and similar topics, are disappointingly incomplete, as if Prof. Ingold, having completed the review of the topics which are of personal interest to him, had decided that the remainder of theoretical organic chemistry was of minor importance. This is certainly untrue, for problems of acid–base catalysis, the roles of Lewis acids in electrophilic substitution, and synthetic applications of the generalized Claisen-type reaction

are as essential to organic chemistry as are aliphatic substitution processes. There are, however, other excellent monographs which deal with these subjects, and it is too much to expect of anyone that he should devote the time and energy to discuss the whole of the theoretical background of organic chemistry in equal detail.

Judged as a whole, "Structure and Mechanism in Organic Chemistry" is a classic of scholarship which will for a long time be regarded, in Britain at least, as the authoritative treatise upon theories of heterolytic reactions. It does mention that there are also homolytic reactions, but refrains from any discussion of them. As has been pointed out, it must be recognized that the book advocates a particular point of view; but since this is that of the scientific worker who is primarily an experimentalist it will receive the hearty approval of all who call themselves chemists. Prof. Ingold's admirers have hoped for a long time that he might eventually be induced to write a book such as this: in its detail and wealth of references it certainly surpasses all expectations, while in regard to its clarity of exposition it is typical of Prof. Ingold at the top of his form.

W. A. WATERS

SCIENCE AND RELIGION

Natural Religion and Christian Theology

By the Rev. Charles E. Raven. (The Gifford Lectures 1951, First Series: Science and Religion.) Pp. vii + 224. (Cambridge: At the University Press, 1953.) 21*s*. net.

THE first volume of Dr. C. E. Raven's Gifford Lectures contains a survey of the work of the early naturalists, of its relation to other scientific studies and to the general climate of thought. This historical survey is made for a theological purpose. For Dr. Raven, 'natural theology' and 'natural history' are closely linked, as they were for the great John Ray, who said "Divinity is my profession" and made it the scientific study of the organic world. Ray's attitude was characteristic of British men of science of the seventeenth century, but is not so popular now, when many see themselves as technocrats. His attitude has also been rejected by some theologians, ancient and modern. These theologians of the extreme other-worldly view, and the technocrats, of whom the Marxists are the most consistent, both take the same view of science: the first to condemn, and the second to attribute magical virtues to science. For these theologians the natural world is obscure and unintelligible, if not actually given over to the powers of darkness, and those who profess to study it must do so for greed of gain or from even worse motives. The Marxist, granted his inversion of the criteria of good and evil and the consequent changes in terminology, says the same. Both deny that there is any real natural order or any real natural world to be discovered, much less to excite wonder and admiration. Dr. Raven argues against the theologians that if they were right the doctrine of the Incarnation would be self-contradictory, as would the whole Hebrew tradition about the relation between the creatures and the Creator. He does not trouble to argue with Marxists or technocrats, but treats the scientific side of the matter historically. This is necessary because so much writing on the history of Western science puts physics, especially experimental physics, in the foreground and all the rest dimly in the background. If you do that you practically accept the Marxist view, for experimental physics creates a world of artefacts and considers the world outside the laboratory, if at all, as analogous to that inside. Fortunately, some physicists are not mere artificers and can see that there is a natural order; otherwise there would be a disastrous split between the sciences.

The attitude of the naturalist is fundamentally religious and æsthetic, and, as Dr. Raven indicates, in all probability the first naturalists in Western Europe were the artists. It is an attitude which in its primitive form comes easily to people living under simple conditions closely linked with earth and sea and sky and the living creatures around them. Dr. Raven points to the excellent observation of Nature to be found in Chapters 38 and 39 of the Book of Job and other parts of the Old Testament. On the other hand—and this is a point he might have made more explicit—this attitude does not come at all easily to unfortunate people whose horizon is confined to the modern industrial urban conglomeration of artefacts.

Valuable features of the book are the tribute to the neglected sixteenth-century naturalist, Conrad Gesner, and to the Cambridge Platonists, who mediated between science and religion during the seventeenth century. Altogether this is a fascinating and illuminating book.

A. D. RITCHIE

A REVIEW OF THE PLANT KINGDOM

Plant Morphology

By Prof. Arthur W. Haupt. (McGraw-Hill Publications in the Botanical Sciences.) Pp. ix + 464. (London: McGraw-Hill Publishing Company, Ltd., 1953.) 64*s*.

THE title of Prof. Haupt's new book, while admittedly correct, is perhaps rather misleading, and plant taxonomy might have been a more appropriate title. It is a survey of the principal groups of the plant kingdom, all of which are dealt with from the point of view of structure, reproduction and development. It is intended to be used as a two-semester course, supplemented by appropriate practical work, and a good general elementary knowledge of botany is assumed. For students in Britain it should comfortably cover most of the systematic botany needed for a general degree.

The author has ranged widely over the plant kingdom and finds room to include most groups in more, or less, detail. In so doing, some will feel he has thrown his net rather too widely. Some groups, like the Isoetales, Psilotales and Laboulbeniales, or even more, the Acrasieæ and Labyrinthuleæ, and, perhaps, one or two of the algal groups, might with advantage have been left out. In little more than four hundred pages, of which a good deal of the space is occupied by illustrations, there is none too much room for so large a project, and, for the type of student for which the book is intended, it might have been preferable to give a little more space to some of the larger groups. On the other hand, it may be contended that the book should be used as a reference book as well as, or perhaps rather than, a text-book, and that the inclusion of such groups as

those mentioned, if only for brief mention, is desirable. Certainly with the short but carefully selected bibliography, a student should have no difficulty in supplementing the information which he is able to obtain from this book.

It is a pleasure to pick up a new book, and an American one at that, which uses an old and familiar classification, and justifies so doing. Rhodophyceae and Phaeophyceae still serve, in place of the newer but less euphonious Rhodophyta and Phaeophyta, while few will regret that the author has not found it necessary to use the term Tracheophyta.

There are more than three hundred illustrations, of which about two-thirds are original. These illustrations, as a whole, are of high quality and form a valuable part of the book. The photographic illustrations are particularly clear.

Any reviewer might glance through Prof. Haupt's book and discover features which he did not like or on which he felt he might improve. Nor would it be difficult to direct attention to errors and to statements capable of misconstruction. To do so would be less than fair to the author. By modern standards, he has undertaken a big task and one which might have been farmed out among specialists; but in that way the book would not have achieved an individuality, and that it undoubtedly possesses. F. W. Jane

PHYSIOLOGY OF THE ALGAE

The Metabolism of Algae

By Dr. G. E. Fogg. (Methuen's Monographs on Biological Subjects.) Pp. x+149. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1953.) 8*s*. 6*d*. net.

THE extreme diversity among the algae has presented a compelling challenge to the development of classical phycology based primarily upon studies of morphology, life-history, taxonomy and ecology. A few algae have been selected for the physiological study of cellular processes such as photosynthesis and various aspects of membrane phenomena. Yet there have been few attempts to seek out and define those general or comparative aspects of physiology which characterize the group. The only two reviews of the subject, by L. R. Blinks[1] and J. Myers[2], did not appear until 1951 and were so limited in the field covered and divergent in point of view that they showed very little overlap. It is timely and appropriate that a more complete treatment of metabolism, the central core of algal physiology, should come from Dr. G. E. Fogg, an active member of a vigorously contributing group in University College, London.

The introductory chapter presents an abridged classification of algae and a classification of nutritional types which provides the basis of organization of the following chapters. Photosynthesis is presented as a necessarily brief survey of a large body of information. The attempt is directed toward exposition of the essential features of the process and the variations in terms of pigment participation and hydrogen donors observed among the algae. A chapter on chemotrophic assimilation provides a more complete synthesis of scattered observations and considers the spectrum of relationships between photosynthetic and oxidative assimilation of carbon. The topic of nitrogen assimilation includes consideration of nitrogen fixation in the blue-green algae and ammonia and nitrate assimilation as observed principally in *Chlorella*. Amino-acid requirements now known for species of *Euglena* and *Chlamydomonas* are treated separately in a short chapter, together with the few known cases of vitamin requirements, under the title of heterotrophic assimilation. The carbohydrate, lipide and nitrogenous cell constituents are considered both as products of metabolism and as distinguishing biochemical characteristics of the various algal classes. A chapter on growth and metabolism is concerned with their inter-relationships. The thesis is set forth that, as a result of minimal excretion and versatile metabolism, changes in environmental conditions may give rise to a great range of variability in cellular composition in the simpler algae. A final four-page summary chapter presents the necessary apology for the limited sampling of algae on which generalizations must be based and reiterates some of the salient ideas of previous chapters in justification of algal metabolism as a distinct field of study.

Since the book will have impact upon future treatments of the subject, criticism should be made of the nutritional nomenclature upon which it is organized. The 1946 Cold Spring Harbor Symposium on Quantitative Biology proposed an elegant and precise classification of nutritional types of microorganisms[3]. The nomenclature was later applied to the protozoa by A. Lwoff[4] and now is applied to the algae by Dr. Fogg. Thus algae may be classified as phototrophs or as chemotrophs, depending upon whether the chief energy source is provided by photochemical or chemical reactions. Subclasses of photo- or chemo-lithotrophs or photo- or chemo-organotrophs are distinguished by their requirement for inorganic or organic exogenous substances. The classical terms 'autotrophy' and 'heterotrophy' are relegated to what is now a minor distinction based upon ability to synthesize essential metabolites. However precise the classification and however logical it may have appeared in 1946, there are now arguments against its continued use. It is cumbersome in terminology. It has had only limited acceptance in the field of microbiology for which it was designed. It does not necessarily group together organisms most closely related metabolically, and its separation into different groups implies far more profound differences than actually may occur. For purposes of discussion of metabolism of the algae, the classification is not a necessity, and at several points it leads to awkwardness of organization. Question is raised as to the desirability of its continued use.

The book is broader in its scope than a review. At the same time, its small size precludes the detailed treatment of data and the criticism and speculation which might be expected of a more exhaustive treatise. It is not directed toward the specialist in the field. It will orient but will not critically instruct the student who desires to work in the field. It serves well the stated purpose of bringing together the scattered literature "into a general account of the subject which will be of interest to students of botany, microbiology, and biochemistry".

J. Myers

[1] Blinks, L. R., "Physiology and Biochemistry of the Algae", 263–291; in "Manual of Phycology", ed. by G. M. Smith, chap. 14. (Waltham, Mass.: Chronica Botanica Co., 1951.)
[2] Myers, J., *Ann. Rev. Microbiol.*, **5**, 157 (1951).
[3] Cold Spring Harbor Symp. Quant. Biol., 11, 302 (1946).
[4] Lwoff, A., "Biochemistry and Physiology of Protozoa", 1–26. (New York: Academic Press, Inc., 1951.)

AIRBORNE MAGNETIC SURVEYS

ON November 27 the Royal Astronomical Society held a Geophysical Discussion, with the Astronomer Royal, Sir Harold Spencer Jones, in the chair, at which the post-war development of a method of carrying out magnetic surveys from the air was reviewed. So far, experience has been mainly confined to measurements of the variation of the total intensity of the geomagnetic field; but experiments with apparatus for measuring three components of the geomagnetic field are in progress in the United States, Canada and Great Britain.

Mr. J. Squires, of the Research Laboratories of Elliott Brothers (London), Ltd., described the 'fluxgate' measuring element, which consists of a high-permeability core surrounded by an a.c. energizing winding able to drive it into saturation. Since saturation occurs twice per cycle, an output signal composed of even harmonics of the drive frequency is generated, predominantly second harmonic when the core is only just saturated but containing up to the fortieth harmonic when driven well beyond saturation. In either case the presence of an external field affects the output which, after rectification, may be used for indicating the intensity of the field component along the axis and its sense. Mr. Squires gave details of the design and operation of fluxgate instruments, the sensitivities of which, under laboratory conditions, are 10–12 $\mu V./\gamma$ and 35–40 $\mu V./\gamma$ for the second harmonic and peak types, respectively. Corresponding noise-levels are 0·03 γ and 0·1 γ.

When used in aircraft, the measuring element is aligned along the earth's field by two other fluxgates mounted mutually perpendicular to it, the whole orientated by servo-mechanisms which maintain the two latter elements in zero-field conditions. In order to measure very small changes in fields, it is necessary to 'back-off' most of the main field, and this may be done by an auxiliary winding on the core fed from a temperature-stabilized battery. Drifts of less than 3 γ per hour are attainable. The fluxgate measuring-head may be either towed from, or mounted in a suitable part of, the survey aircraft. In the latter case, compensation for the aircraft's own field is necessary and may be achieved with small permanent magnets or strips of high-permeability material. 'Noise-level' after compensation is usually 1–2 γ. Mr. Squires mentioned that another form of measuring element, dependent on the change in a.c. resistance of a high-permeability wire when subjected to a magnetic field, might have applications in airborne survey work.

Mr. A. B. Malone, of the Anglo-Iranian Oil Co., Ltd., stated that the oil industry is interested in outlining deep sedimentary basins, where sufficient sediments might exist to permit oil accumulation. He thought that there is a good deal of over-optimism in the United States as to the ability of the airborne magnetometer to define depths to the crystalline basement and even to outline structure in the overlying sediments. From the nature of magnetic data, there can be no such certainty of interpretation. Depth calculations can be of two kinds. If the field is continued downwards until the anomalies become impossibly great, or if the magnetic anomalies are assumed to arise from 'point' sources, maximum depths can be assigned. Alternatively, one can assume the form of the causative body and calculate depths to the body on that assumption. It is this latter method which has proved so successful in America. The anomalies are assumed to arise from large rectangular blocks having a different susceptibility from the surrounding basement rocks. The walls of the block are assumed to be vertical and extend downwards to great depths. It seems unlikely that the basement could everywhere be imagined to be of this nature; and, in fact, total magnetic intensity maps show that over large areas of the world it is not, as the anomalies are small in lateral extent and very irregular in pattern. When the depth of the basement increases, the anomalies merge into one another to produce finally a smooth picture with no anomalies of any magnitude. This is in marked contrast to the large regular anomalies found in the Bahamas and on the American continent over sedimentary strata exceeding 20,000 ft. in thickness.

On depth calculations in general, Mr. Malone said that the ordinary methods of Vacquier[1] would be of doubtful utility in such an area, as it is obvious that, with increasing depth to the basement, the anomaly pattern becomes smoother as the sharp anomalies merge into one another. One method, which appears to be useful in certain areas, is to select a part of the total intensity map where basement depths are known or could be estimated, and measure the average 'sharpness' of the anomalies over that part of the map. The total intensity map of this area is then extrapolated upwards, and the mean sharpness again measured at various heights. This enables the sharpness criterion to be related to depth, and the depths to basement over the whole area of the map can then be roughly estimated. In order that isolated values of the sharpness should not be given undue weight, some smoothing of the final map may be desirable. In areas such as the Bahamas, Mr. Malone thought that the anomaly pattern is such that Vacquier's methods would be applicable, although this has not been examined. This area was surveyed before the publication of Vacquier's book, and a different method was used. Here the anomalies were supposed to arise from truncated cones, and magnetic fields for a series of such cones were calculated and compared with the observed anomalies.

Mr. H. F. Finch, of the Royal Greenwich Observatory, referred to some observations recently made in America, where an airborne magnetometer has been employed to measure absolute intensity and direction of the magnetic field. From these measurements it is possible to calculate the values of the other elements. The results obtained appear, in general, to be good within $\frac{1}{4}°$ in declination, and to within 200 γ in the horizontal and vertical components of the earth's magnetic field. Mr. Finch has been able to confirm this order of accuracy from a comparison of some of the airborne results, corrected for the effect of altitude, with land observations made in the same regions. The general pattern of the field, as given by the airborne observations, is also in good agreement with that reduced synthetically from the results of a spherical harmonic analysis made at the Royal Greenwich Observatory in the course of preparing the Admiralty Magnetic Charts for the epoch 1955.0.

Mr. P. A. Rankin, of Hunting Geophysics, Ltd., London, described the execution of an aerial magnetic survey. His organization used a Canso flying boat with the magnetometer head in a fixed position

under the tail. Latterly, a Percival Prince aircraft has been converted; the magnetometer head is fixed in the tail and is a universal one which can be used in any latitude, for low or high magnetic dip. The positioning is done by a 35-mm. cinó camera, which exposes film at such intervals that the whole of the ground beneath the aircraft is recorded, the magnetometer record being marked at each film exposure. Generally, where the object is to outline geological bodies which lie close to the surface of the ground, the spacing of the magnetic profiles is of the order of ¼ mile and the flights are made at a height of 500 ft. above ground. However, where the magnetic material is deeper, as in the case of mapping the basement underlying oil areas, the spacing can be 1, 2 or 4 miles and the height can be a constant at 1,500–2,000 ft. above sea-level. The technique of magnetic control is to fly a series of lines, called control lines, around a network of fixed magnetic values, which act as datum values for the readings on the flight lines themselves. Where there are areas of low magnetic relief, this method is practical; where, however, the area is magnetically disturbed, it may only be possible to use selected points instead of lines. Whichever method is used, the aircraft flies over these points or over a series of points (called 'loop points') at least twice within, say, ten minutes. This allows the diurnal drift of the field over that period to be calculated. It is, of course, assumed that the daily variation is linear for that time period. A stationary magnetometer of the fluxgate type is run at the flying base so that during a magnetic storm flying can be stopped. Esterline–Angus curvilinear tape 5 in. wide was the early type of record used; the Leeds–Northrup tape, rectilinear 10 in. wide, has latterly been used, allowing for an easier reduction of data.

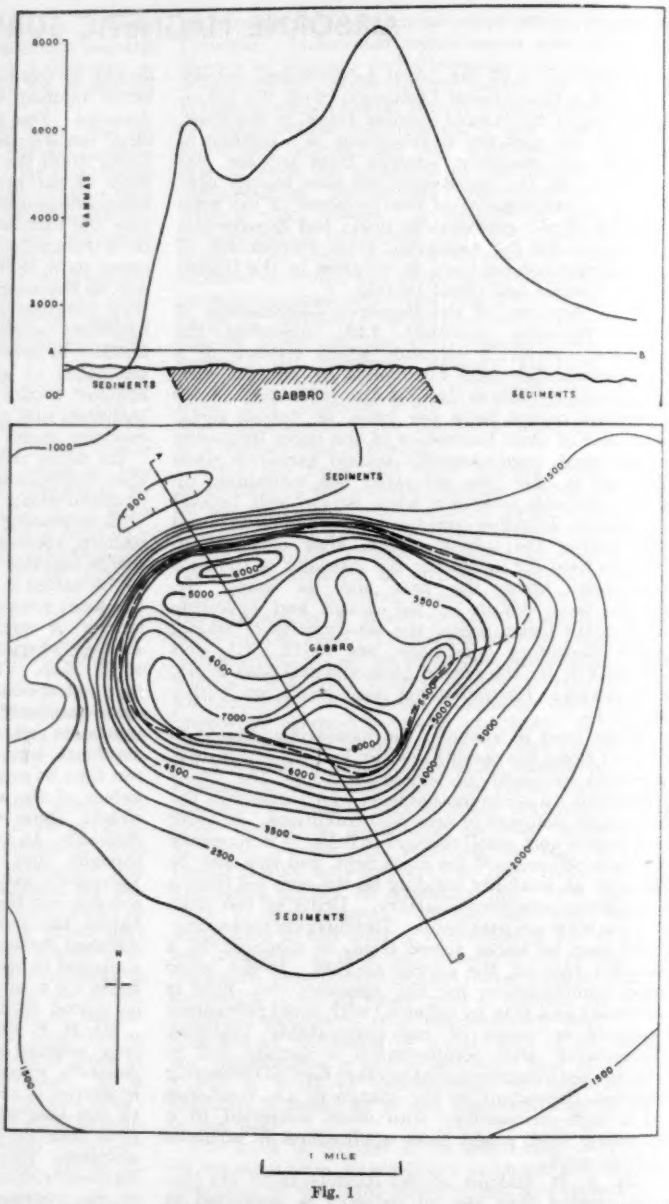

Fig. 1

Next, Mr. Rankin described the reduction of the data obtained to produce total-intensity maps. The control network values must be determined, errors of closure around the network distributed and final values marked on the control lines, as plotted on the map. Values at intersections of control and flight lines are then determined, and thus values along the flight lines are determined and marked on the map and the contours finally sketched in. Mr. Rankin then illustrated how simple geological structures appear on aerial magnetometer maps (Figs. 1 and 2). Fig. 1 shows a strongly magnetic gabbro plug outlined on an airborne magnetometer map at 500 ft. altitude. The direction of plunge, known from geological work, can be interpreted from the magnetic profile. Fig. 2 shows a sharp anomaly produced by a sill-like body of serpentinized periodotite. The shoulder on the north-west side of the anomaly is caused by a belt of volcanic strata. The asymmetry of the profile is related to the south-west dip of the serpentine.

Dr. S. K. Runcorn, of the Department of Geodesy and Geophysics, University of Cambridge, pointed out that magnetic surveys are the one type of airborne geophysical survey likely to be available for a long time to come and would be used extensively in hitherto unexplored areas of the world. Their success in picking out ore bodies has been striking, and he

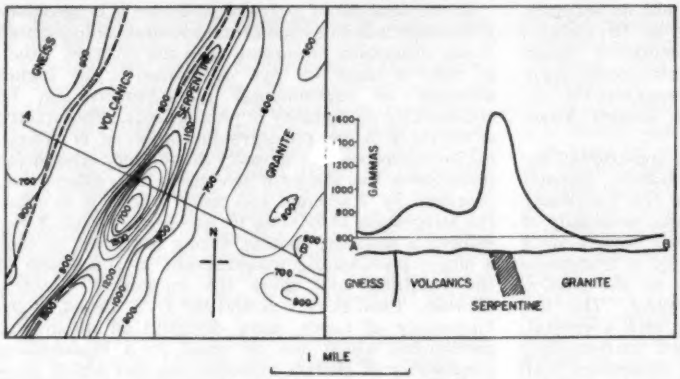

Fig. 2

referred to the discovery by the Aero Service Corporation of Philadelphia, using such surveys, of an extensive iron-ore body beneath the property of the Bethlehem Steel Co. at Morgantown, Pennsylvania. This body lies under 1,500 ft. of limestone, and previous extensive geological and ground survey failed to locate it; it is apparently dangerous to under-estimate the economic potentialities of this new method of exploration.

Apart from the well-marked magnetic anomalies of such ore concentrations, one has mainly to consider the anomalies caused by the surface contours and polarization variations of the basement rocks. Usually highly contorted and of igneous or plutonic origin, these rocks will have high intensities of magnetization (approximately 10^{-3} gauss) due to a high content, a few per cent, of iron oxides and due to the thermoremanent magnetization acquired on cooling after deep burial or metamorphism or from a magma. Apparently such thermoremanent magnetization is greater than the induced magnetization in the earth's present magnetic field, and as there is now much evidence that the direction of the field, both in declination and dip, has varied considerably over geological times, the validity of the interpretation of magnetic anomalies in terms of variations in intensity, but not in direction, of the polarization of the basement rocks is in some doubt. Some of the ferromagnetic constituents of rocks are unstable magnetically, and the polarization of rock samples containing these oxides will rotate into the direction of the field in which they are placed. Such effects may be more general at the higher temperatures at depth, and over long times, and the assumption of a basement magnetized along the present direction of the geomagnetic field may in the end be justified. The sedimentary stratum covering the contorted basement rocks is often flat-lying and normally has a low intensity of magnetization (say, 10^{-6} gauss) owing partly to the segregation of the heavy minerals due to erosion and deposition and the absence of effective processes of magnetization as in the case of igneous rocks.

Scientifically, airborne magnetic surveys are of enormous interest in view of the rudimentary nature of our knowledge of the structure at depth and especially the differences between the oceanic and continental areas. It has been pointed out by Deel[2] that there are apparently no anomalies of intermediate extent between those which can plausibly be attributed to the current systems of the main geomagnetic field in the depths of the mantle and core and those anomalies the origin of which lies in the ferromagnetism of the crust. Consequently, the depth to the Curie-point isotherm where rocks cease to have ferromagnetic properties bears a relationship to the width of the magnetic anomalies observed at the surface. Recently, the discussion of the temperature distribution and radioactivity heat generation in the earth's crust has been renewed by the discovery that the geothermal gradient in the ocean bottoms seems to be nearly the same as that in the continents, despite the absence of a granitic layer of relatively high radioactive content. Consequently, the depth of the Curie-point isotherm under the oceans and the continents may be very different, and a comparison of the width of the magnetic anomalies obtained over oceanic and continental regions, such as could be easily obtained by the total-intensity aerial magnetometer, would be of great interest.

Dr. Runcorn concluded by suggesting that an aerial magnetic survey of the British Isles is much needed for comparison with the wealth of geological and gravitational data available. S. K. Runcorn

[1] Vacquier, V., Steenland, N. C., Henderson, R. G., and Zietz, I., Mem. 47, Geol. Soc. Amer. (1951).
[2] Deel, S. A., Pap. U.S. Coast Geod. Surv., No. 664 (1945).

THE R. W. PAUL INSTRUMENT FUND

UNDER the will of Mr. R. W. Paul, who died in March 1943, the R. W. Paul Instrument Fund was established, and in 1945 a committee was set up composed of three representatives of the Royal Society and one each of the Physical Society, the Institute of Physics and the Institution of Electrical Engineers. This committee is empowered by the terms of the Trust to receive applications from British subjects who are research workers in Great Britain for grants for the design, construction and maintenance of novel, unusual or much-improved types of physical instruments and apparatus for investigations in pure or applied physical science. These grants may be made for or towards the provision of equipment, building facilities or financial or other aid, in such a manner as the committee may determine; but grants from the Fund may not be used to relieve expenditure in any establishment controlled by the Government or to relieve any university or other educational establishment of its normal financial obligations.

Since its inception the committee has voted £56,350 in respect of some eighteen instruments, some of which are mentioned below.

The mechanical forces exerted by electromagnetic fields have been applied to the measurement of microwave power in work now in progress by Prof. H. M. Barlow and Dr. A. L. Cullen in the Electrical Engineering Department, University College, London. A practical torque-operated wattmeter for the absolute measurement of microwave power in the

range 10–60 W. at 3 cm. wave-length with an accuracy of about 1 per cent has been devised by Dr. Cullen; its calibration involves measurements of mass, length and time only. Efforts are now being made to use electrical and mechanical resonance for the measurement of smaller powers at shorter wave-lengths.

A vibration gravimeter has been constructed by Mr. B. C. Browne and Mr. R. L. G. Gilbert, Department of Geodesy and Geophysics, in the University of Cambridge. The gravimeter consists essentially of a vertical filament tensioned by the weight of a constant mass. The natural frequency of transverse vibrations of the filament depends on the tension and hence on the local value of gravity. This frequency is measured by comparison with a crystal-controlled frequency standard. Even if the frequency fluctuates, the average value can be determined with an accuracy better than one part in a million. The gravimeter can therefore be used on an unsteady support. It has been used to measure gravity in a submerged submarine[1] and has now been adapted for remote operation for investigating the vertical gravity gradient in a borehole[2].

In Lord Cherwell's laboratory at Oxford two spectrometers have been developed. One, a photoproton spectrometer, measures the energy of gamma-rays above 2·2 MeV. Photoprotons are produced by gamma-rays in a deuterium-filled (5 atmospheres pressure) ionization chamber. After amplification their pulse-height spectrum is analysed by a 25-channel kicksorter. Mono-energetic gamma-radiation will produce a single photoproton peak, and not a continuous pulse-height distribution. It is possible to detect very weak radiation in the presence of a strong background of radiation of lower energy. In this way a new line in the spectrum of sodium-24 at 3·7 MeV. (intensity 1/2,500) was found[3]. The energy of a photoproton depends on the angle of emission with respect to the beam. This makes it possible to determine the angular distribution by analysing the shape of the pulse-height, which is of theoretical interest. Measurements have been made for gamma-energies of 2·76, 2·62, 2·51 MeV.[4]. The techniques and equipment developed for this instrument are also used in connexion with the investigation of gamma-rays with a Compton spectrometer and a pair spectrometer[5,6].

The energy of fast neutrons is usually determined from the spectrum of recoil protons (hydrogen-filled ionization chambers, organic scintillating crystals, photographic plates). These methods have the common disadvantage of poor resolution and difficulty in the interpretation of results. In the fast neutron spectrometer developed, only those recoil protons are selected which have suffered a head-on collision. This is achieved by measuring coincidences between pulses produced by recoil protons due to the primary neutrons in a stilbene crystal and pulses produced in a sodium iodide crystal surrounded by a layer of silver (1 cm.) by capture gamma-rays from the scattered neutrons. By means of a time delay (3×10^{-9} sec.) neutrons which have lost at least 99 per cent of their energy in the stilbene are selected. The instrument gives a peak for mono-energetic neutrons, not a continuous spectrum. It has an energy resolution of 5 per cent at 2·5 MeV. This instrument has been adapted for the measurement of the energies of low-lying levels of nuclei excited by the inelastic scattering of fast neutrons[8].

In the analysis of a crystal structure it is necessary to measure hundreds and even thousands of integrated X-ray diffraction intensities from the crystals. Much of this is done by eye estimation; but higher accuracy of experimental measurement can be achieved by photometry of photographs. Photometry of ordinary X-ray photographs, however, is exceedingly tedious because no really satisfactory integrating photometer has yet been produced. The alternative, proposed by Wiebenga and Smits (1950), is to cause the integration to be done by giving the actual X-ray camera a scanning motion during exposure, so that a single photometric measurement in the centre of the resulting spot gives the integrated intensity directly. Prof. E. G. Cox and Mr. D. S. Beard, of the University of Leeds, have designed an integrating mechanism which can be fitted to a Weissenberg goniometer of British manufacture and which gives results of high accuracy. Although the mechanism is costly to make, it eliminates the need for an even more costly photometer, since a very simple photometer suffices for the measurements required; and although it increases the time needed for taking X-ray photographs, it reduces very greatly the time required for their measurement.

The purpose of an interference microscope constructed by Dr. D. Gabor, of the Electrical Engineering Department, Imperial College of Science and Technology, London, is to obtain a complete record of microscopic objects in two photographs; moreover, these records are obtained with a small fraction of the illumination required in ordinary instruments, by making use of an amplification principle. It is hoped that ultimately this may be used in the microscopy of light-sensitive organic structures. In the new microscope a coherent light beam is split into two unequal parts. The smaller part passes through the object, which is in one branch of an interferometer, while the larger part, the 'coherent background', passes through the other. Each beam is split into two, and a quarter-wave phase shift is produced between the two background-beams. These are then paired with the two image-carrying beams, and produce two photographs on a plate, side by side. Whether the object is focused on the plate or not, these two photographs contain a complete record of the image wave. The densities in corresponding points are proportional to two amplitude components, in quadrature with one another. Reconstruction is carried out in the same apparatus by illuminating the photograph with two uniform waves, again in quadrature to one another. The reconstructed beam can be explored in depth, in dark field, bright field, amplitude contrast or phase contrast, just as if one had the original object under investigation.

Prof. A. V. Hill, with Dr. D. K. Hill and Dr. D. R. Wilkie, has been working in University College, London, on new types of galvanometers and radiometers and on apparatus for studying material at high pressure. The problem of constructing galvanometers of short period (for example, 5 msec.) with sufficient sensitivity has been solved by employing photoelectric amplification of the deflexion. The short period requires a very light moving coil, and the high magnification demands extreme freedom from extraneous disturbance. The latter is achieved by (*a*) symmetry of the moving system, involving very accurate construction, (*b*) using alternate springs and masses in the mounting. The magnified deflexion is displayed on a cathode ray tube. Several such galvanometers have now been in use for years,

at sensitivities normally obtained with instruments of 1–2 sec. period.

Two chambers have been constructed for studying the effects of high pressure (up to 1,000 atmospheres) on muscular contraction. These are very satisfactory, the pressure being easily produced. The rapid changes occurring after stimulation must be recorded externally. Difficulties are provided by (*a*) the small size of the pressure chamber, (*b*) having to fill it with salt solution, and (*c*) electric leaks. Moreover, no existing electro-mechanical transducer is suitable for high pressures under these conditions, and new techniques must be devised. These difficulties are being overcome and preliminary results have revealed various interesting new effects.

Dr. H. H. Hopkins, of the Technical Optics Section of the Physics Department, Imperial College of Science and Technology, London, has designed a static scanning fibrescope the aim of which is to provide a flexible unit capable of transporting optical images along its length[8]. Upwards of 50,000 fibres of glass, of a type such as the boro-silicate crowns giving high transmission, are aligned in a regularly arrayed bundle, some 0·20 in. square and 30 in. long. An optical image formed on one end-face of the bundle is now transferred to the other end, since the light falling on any one fibre is 'trapped' in that fibre because of total internal reflexion. A transmission of 25–50 per cent is expected in the final instrument; and already, even using coarser fibres, detail 0·005 in. in size can be resolved and the image is of good contrast. A particular use in view for the fibrescope is gastroscopy and similar medical techniques.

A small diffraction-grating ruling engine is being built by Dr. A. H. Holbourn and Prof. R. V. Jones, of the University of Aberdeen, to test the possibility of controlling the line spacing by direct reference to a light-wave interference pattern. This would eliminate the errors arising from the use of a screw. The pilot model is intended to produce concave gratings 8 cm. × 5 cm.; the absence of periodic errors should give ghost-free spectra. The technique of using light waves directly for mechanical control, which has been developed specially for this ruling engine, may have other applications.

Dr. O. Klemperer, of the Physics Department, Imperial College of Science and Technology, London, has constructed an electron spectrometer of high resolving power which will be useful whenever fine structures in any electron spectrum have to be investigated. The instrument uses a short magnetic deflexion field of very small aberration for the dispersion of the electron spectrum. A magnetic lens forms an intermediate image of the source closely in front of the deflexion field, while the deflexion field, acting as an astigmatic lens, projects the final image of the source on the collector slot. The spectrometer can be used for beta-rays of 10^6 eV. For weak beta-sources, the greatest possible collecting power is required, and for this purpose a four-pole magnet has been used. This is inserted between the deflexion field and collector slot in order to counteract the astigmatism of the deflexion field and so to shorten the line image down to the length of the collector slot. A resolving power of about 1,000 has been obtained with a collecting power of about 1/1,000. The spectrometer is being used at the moment for an investigation on quantum losses of electron energy at inelastic collisions in solids. Electrons of only 5–10 keV. are transmitted through thin films, and discrete losses of 10–20 eV. are measured. Here an increased resolving power is obtained by decelerating the rays down to 800 eV. before they enter the deflexion field. In this way the resolution has been increased sufficiently to locate the lines in a spectrum of a 10-keV. beam within a fraction of a volt.

A team of workers under Prof. N. F. Mott in the University of Bristol is developing a meniscus Schmidt meteor camera—a camera of wide aperture and short focal length, with a large field. After experience obtained with a small camera made from plate glass (aperture 6·5 in., *F*/0·7 (nominal)), the construction of a small-scale pilot model was commenced and is now nearing completion and should be ready for use this March. This will have a focal ratio of *F*/0·63 (nominal) or *F*/0·78 (effective), with a field of 56°. The stop diameter is 8·6 in. (focal length 5·4 in.) and mirror diameter 17 in. The full-scale model will have a mirror of diameter 28 in. The lens and mirror systems of these cameras have been designed independently; it has not been possible to compare them with the American models, full details not being available. The shutter system is original and avoids drilling holes in the mirrors through which to pass the rotating axle; the use of curved photographic plates is also unique to the Bristol instrument, the coating of these plates having been already accomplished successfully. The camera will be used in conjunction with the radar equipment at Jodrell Bank, Cheshire, to photograph meteors; a rotating shutter enables velocities to be measured. Information such as luminosity, velocity and decelerations will be obtained. From these observations, physical conditions in the upper atmosphere and collisions between molecules of high energy can be investigated.

A conventional spectrometer, in which the detector scans the elements of the spectrum one at a time, is inefficient in that only one element out of the whole spectrum is actually being observed at any moment. In the multichannel spectrometer being constructed by Prof. R. O. Redman at the Observatories, University of Cambridge, this loss is avoided by applying modulation patterns to the intensities of the spectral elements in such a way that they may act on a single detector simultaneously throughout the whole time of observation and yet be separable at the output of the detector. In the instrument under construction, the modulation is effected in a two-beam interferometer without the use of any dispersing system such as a prism or grating. The multichannel spectrometer should be specially valuable for faint radiation sources in the infra-red, and if successful will ultimately be applied to infra-red stellar spectra.

Information about application for grants from the R. W. Paul Instrument Fund can be obtained from the Assistant Secretary, Royal Society, Burlington House, Piccadilly, London, W.1.

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[3] Beghian, L. E., Bishop, G. R., and Halban, H., *Phys. Rev.*, **83**, 186 (1951).
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THE ADULT FEMALE LOWER JAW FROM MAKAPANSGAT

By Prof. RAYMOND A. DART
University of the Witwatersrand

In Makapansgat Valley near Potgietersrust in the Central Transvaal on July 29, 1953, Mr. Alun R. Hughes, senior technician in the Department of Anatomy, University of the Witwatersrand, recovered from the Limeworks dump, which has previously yielded cranial and pelvic remains of adult, adolescent and infantile specimens of *Australopithecus prometheus*, the major portion of an undistorted adult and probably female mandible.

The accompanying photograph (Fig. 1) illustrates first the specimen itself and secondly its appearance (below) in comparison with (above) the infantile *A. africanus* mandible from Taungs (Dart, *Nature*, 1925) and (centre) the adolescent *A. prometheus* mandible from Makapansgat (Dart, *Amer. J. Phys. Anthrop.*, 1948).

These three australopithecine mandibles, collected during the past thirty years, fortunately are all undistorted. Each preserves virtually the entire dentition at the crucial growth stage it represents. Simultaneously, they display collectively the anatomical details of the lower jaw and its dentition in a complete and unqualified fashion. The growth process as well as the form of the australopithecine mandible, both subsequent to and preceding the establishment of the milk dentition, was indistinguishable from that which occurs in mankind.

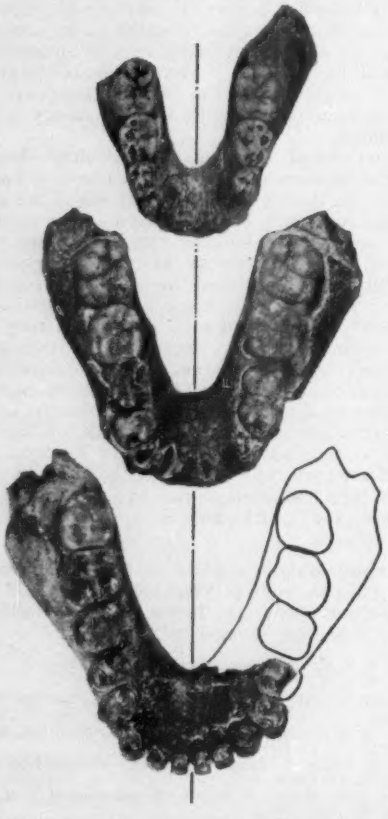

Fig. 1. Upper: infant *Australopithecus africanus* (Taungs). Middle: adolescent *Australopithecus prometheus* (Makapansgat). Lower: adult female *Australopithecus prometheus* (Makapansgat). × 3/5

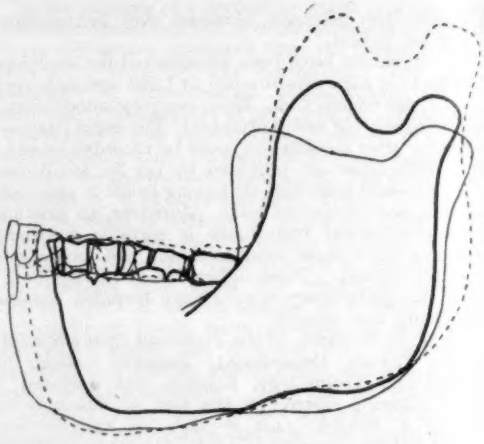

Fig. 2. Outlines of jaws of: *Australopithecus prometheus*, ——; *Paranthropus crassidens* ♀, - - - -; Heidelberg man, ——. × 3/5 natural size

The new adult jaw is unique at the moment, because it is the only one so far to have preserved the entire incisor–canine–premolar–molar dental arcade without warping, compression or dental dislocation. Although the lower third of the symphyseal region was blasted away, little of the essential anatomy of the jaw is lost. From the adult occipital and craniofacial, and the adolescent mandibular fragments of *A. prometheus* recovered in 1947 and 1948, a provisional reconstruction was made available in 1950 to all museums and anthropologists at cost, through the generosity of the American Institute of Human Paleontology and the Wenner-Gren Foundation which assisted in founding it. It is gratifying to record that scarcely 2 mm. alteration is necessary in the dimensions of the profile, or norma lateralis, of that reconstruction for its mandibular contour to correspond with that of the specimen now under discussion.

The most remarkable feature of this, the most nearly human of all known South African man-ape dentitions, is that the dental arcade can be superimposed tooth for tooth upon the dental arcade of Peking man. The dental length in the promethean man-ape is actually less. The chord of the dental arcade from the mesial border of the medial incisor to the distal border of the third molar measures 75 mm. in Peking man and only 73 mm. in the Makapansgat man-ape. The bicanine width in the *Sinanthropus* male is 37·5 mm. and in the *A. prometheus* female 35·5 mm. The width of the second molar in the primitive man from China is 14·0 mm. and in the proto-human individual from the Transvaal 14·5 mm. Actually, the Makapansgat premolar–molar series of teeth is slightly larger, while the incisor–canine series is slightly smaller, than the corresponding Peking series.

The Makapansgat mandible is shorter and more robust than that of Peking man, but definitely much shorter and less robust than those of its near South African relatives *Plesianthropus* and *Paranthropus*,

showing the wide range of potential variation at the australopithecine phase of human evolution. The really astonishing fact, however, is that this mandible is considerably smaller (see Fig. 2) than the mandible of Heidelberg man. There is no satisfactory means of distinguishing the lower jaw or its teeth in *Australopithecus prometheus* from those of some of the primitive human beings already known to science.

In their jaws and dentitions as in their postural uprightness and predaceous habits, the South African man-apes were human. There is no known criterion whereby the Australopithecinæ can be excluded from the zoological status of an intermediate family of creatures having the brains of apes and the bodies and nutritional habits of mankind.

OBITUARIES

Prof. Robert A. Millikan

THE distinguished American physicist, Dr. Robert A. Millikan, died on December 19, after an illness of several months, at his home in Pasadena, California; he was eighty-five years old. Dr. Millikan was born in Morrison, Illinois, on March 22, 1868, the second of six children. His father, Silas Franklin Millikan, was a Congregational minister. Before her marriage, his mother, then Mary Jane Andrews, was Dean of Women of Olivet College, Olivet, Michigan.

Millikan attended Oberlin College at Oberlin, Ohio, where he received his A.B. degree in 1891 and his A.M. degree in 1893. He held a research fellowship at Columbia University during 1893–95, when he received from that institution his Ph.D. degree. The following year he continued his study and research at Berlin and Göttingen.

In the autumn of 1896 he was appointed an assistant in the Physics Department in the University of Chicago. In his twenty-five years at that University Dr. Millikan progressed through the academic ranks to become one of that institution's most outstanding professors. In 1921 he went to Pasadena, California, as the chairman of the Executive Council of the California Institute of Technology and also served as director of the Norman Bridge Laboratory of Physics. He retired from these positions in 1945, but continued his active participation as a vice-president of the Board of Trustees of the Institute and as a research worker in the Norman Bridge Laboratory.

The Nobel Prize in Physics for 1923 was awarded to Dr. Millikan for his precision evaluation of the electronic charge *e* and of Planck's constant of action. The Hughes Medal of the Royal Society, the Comstock Medal of the U.S. National Academy of Sciences and many awards, honorary degrees and academy memberships have clearly shown the world-wide recognition and distinction that he deserved and received. His most important contributions were in the measurement of the charge of the electron, the photoelectric determination of Planck's constant, the bridging of the gap between the ultra-violet and X-radiation, and his explorations of cosmic radiation. In addition to these major fields of research, Millikan contributed substantially to many other fields. With unusual physical stamina and energy, he was able to spend more than sixty years in active participation in physical research. It was characteristic of most of his research that many hours of painstaking observation and analysis were required for the problems undertaken. Measurements made with great care were repeated many times to obtain from his equipment the greatest accuracy. Careful analysis of the data yielded experimental facts that enabled him to refine both his equipment and his analysis of the data to give results in physical measurements of remarkable precision. The great variety of fields in which he made important contributions emphasizes his unusual ability in recognizing and developing critical and important areas for research.

Dr. Millikan's contributions to education in the United States brought him many honours and recognition as a great educator. As a college student he taught physics in a preparatory school and found the text-books available unsatisfactory. His first years at the University of Chicago were partially occupied with a programme of writing texts for preparatory school and first-year university courses. His text-books, widely used throughout America for half a century, have been important influences in scientific education. In the creation and development of the University of Chicago he was a strong advocate of the concept that departments should be composed of a group of independent scholars, one of whom, for administrative purposes, is chosen as a chairman. In the California Institute of Technology he developed an outstanding engineering school combined with a very distinguished and able graduate school in basic science. The thousands of graduates of this unique institution are now a very important influence in American technology. The development of the National Research Council was due, in a large measure, to the efforts of Millikan. The post-doctoral National Research fellowships provided a substantial group of able research scientists who were the leaders of the National Defense Research Council and of its projects in the Second World War. Millikan was, himself, an active worker in the military forces in the First World War. In the second his Institute, with many staff members on leave to military and scientific research, carried on a large training programme for military students, and at the same time developed and produced important military weapons.

Millikan began his career at the time of a great revolution in physics. He witnessed and participated in the initial discussions regarding the nature of cathode rays, X-rays and radioactivity. The radical ideas of the quantum theory and of the theory of relativity were supported enthusiastically by the young Millikan.

The period following the First World War was a transition period for the world, and also for Dr. Millikan. The practical applications of scientific discoveries had led to such radical changes in transportation, in communication, and in industrial and chemical production that the century was marked as the scientific era. The homage paid to science for the part it has played in changing our concepts of matter and life brought on an attack from those who saw a conflict between science and religion (for example, the 'monkey trials' in Tennessee). With Millikan's move to the California Institute of Technology he became the spokesman for those who believed that science was neither materialistic nor irreligious. In taking this conservative position, Millikan received great acclaim from many religious groups. In assessing his own success, Millikan gave credit to Divine guidance or a "good fairy" for the opportunities that came to him.

His wife, Greta Blanchard Millikan, died two months before his own death. His eldest son, Clark

B. Millikan, is professor of aeronautics at the California Institute of Technology. His second son, Glenn A. Millikan, who was professor of physiology at Vanderbilt University, was killed in a mountain-climbing accident in 1947. Glenn Millikan's wife was Claire Mallory, daughter of George Leigh Mallory, the Mount Everest climber. His youngest son, Max F. Millikan, is professor of economics in the Massachusetts Institute of Technology.

Robert B. Brode

Prof. Oldřich Tomíček

Prof. O. Tomíček's death, which occurred after a short illness on October 21 a few days after his sixty-second birthday, is a heavy blow to Czechoslovak analytical chemistry, for during the past twenty-five years he has been the leading analyst and pharmacist at the Charles University. He was born in Prague on October 10, 1891, where his father was a pharmacist, and early showed his scientific ability in publications with Prof. B. Brauner. Thus young Tomíček was predestined to the study of pharmacy and reached the degree of *Pharmaciae Magister* shortly before the outbreak of the First World War, in which he had to serve in a military pharmacy in Innsbruck. It is significant of the zeal of the young scientist that he found an opportunity of approaching Prof. K. Bruner to pursue special work on indol derivatives in the laboratories of the University of Innsbruck. The end of war brought Tomíček back to Prague and gave him the chance to widen his scientific knowledge at the Charles University under the guidance of the inorganic chemist Prof. Štěrba-Böhm. Here he took the degree of Ph.D. in June 1920 and was appointed university assistant. The years 1923–24 Tomíček spent in Utrecht in the laboratory of Prof. Schoorl to acquire potentiometry. There started his friendship with the rising scientist, I. M. Kolthoff, which proved most influential for the further development of Tomíček's line of research and lasted—supported by frequent meetings of both men at various international gatherings—until Tomíček's death. The two friends worked out the foundations for the use of titanous chloride in potentiometric titrations.

Later on, as assistant professor of analytical chemistry in Prague, Tomíček worked on the potentiometric determination of cerium and started with his school a series of studies of volumetric determinations in strongly alkaline medium. His chief work in that direction was published in the *Journal of the American Chemical Society* during 1935, where he gave practical applications for the titrations of cobalt, manganese, bismuth, thallium and cerium, using amalgams for the reduction, and ferricyanide, hypochlorite or hypobromite for oxidation. In that year Tomíček was nominated full professor.

In 1943 he started to study potentiometric and polarometric titrations in non-aqueous solutions, chiefly in glacial acetic acid. This line of research required special attention from the theoretical aspect as regards the meaning of neutralizations and *p*H values. These discussions are therefore of high theoretical value and of fundamental interest, promising also possibilities of wide practical applications.

Prof. Tomíček was also held in high regard in pharmaceutical circles, being co-editor of the Czechoslovak "Pharmacopœia" and revising the analytical problems involved. He was expert also in forensic chemistry.

As a university teacher, Tomíček proved an excellent lecturer, devoted to his pupils. For them he wrote in Czech several valuable text-books on quantitative and volumetric analysis. Of his scientific monographs the best known and appreciated is "Chemical Indicators", which was translated into English (Butterworth, London, 1951). Besides this, Tomíček contributed at the international level to the "Handbuch der analytischen Chemie" (J. Springer, Berlin, 1944 and 1948) with accounts on ammonium, oxygen, sulphur, selenium and tellurium. In his own country, also, Prof. Tomíček was highly esteemed. For many years he was president of the Czechoslovak Chemical Society, of which he was made an honorary member, president of the Pharmaceutical Society and corresponding member of the Czechoslovak Academy of Science.

Tomíček was an extremely kindly man, always willing to help his numerous friends, colleagues and pupils, and inclined to overwork himself for unselfish reasons. His non-academic interests were mountaineering, motoring and skiing. Thus not only in scientific minds, but also in many hearts, Prof. Tomíček's death has left an open gap.

J. Heyrovský

Dr. F. C. Minett, C.I.E., M.B.E.

Dr. F. C. Minett, director of the farm livestock research station of the Animal Health Trust, died on December 26 at the age of sixty-three.

Francis Colin Minett was born on September 16, 1890, and was educated at King Edward's School, Bath, the Royal Veterinary College, London, and the Pasteur Institute, Paris. He qualified as a veterinary surgeon in 1911 and worked for the next three years in the pathology department of the Royal Veterinary College under Sir John McFadyean. During 1914–24 Minett was an officer in the Royal Army Veterinary Corps. He then became a research officer of the Ministry of Agriculture's veterinary laboratories until 1927, when he was appointed director of the Research Institute of Animal Pathology at the Royal Veterinary College; in 1932 he became professor of pathology. In 1939 Minett went to India as director of the Imperial Veterinary Research Institute at Mukteswar. On the division of India he became commissioner for animal husbandry in Pakistan until 1949, when he joined the staff of the Animal Health Trust. At the request of the Foreign Office, he was soon seconded for two years as veterinary adviser to the Turkish Government.

Minett was a prodigious worker, mainly upon bacteriological problems concerned with disease in animals. He was a strenuous bench worker throughout his life, although he never neglected—indeed he encouraged—the translation of laboratory work to the farm. His work was mainly concerned with diseases of cattle, and he studied in turn bovine tuberculosis, contagious bovine abortion, Johne's disease, foot and mouth disease and mastitis. He also investigated mastitis in sheep, blackquarter, anthrax, strangles in horses, mortality wastage among livestock in India, and the health of animals as affected by climatic conditions. In all, he published more than fifty papers in scientific journals.

Probably the main work which Minett did was to focus attention on the serious loss in Great Britain occasioned by mastitis in cattle. He divided the

Streptococcus forms into three groups, and it was shown that his Group I coincided with *Str. agalactiae*, information which was already known in other countries. He and his colleagues were the first to point out the etiology of his Group II, which is known as *Str. dysgalactiae*. His Group III is now known as *Str. uberis*. Probably the best defence that Minett ever gave for the work which he and his colleagues did is in an article published in the *Journal of Hygiene*, **35**, 504 (1935). This was in answer to an attempt by some medical bacteriologists to delve into a veterinary problem. His work also included the demonstration that certain human strains of Streptococci could affect the udder of the cow, and in turn that affected milk may cause an outbreak of human disease. He directed attention to the toxin production of *Staphylococci* of animal sources; these differ in some degree from the human pathogens. His work on Johne's disease was largely concerned with methods of isolation and types of media, in addition to collaborating with others in the diagnosis of the disease, particularly by Johnin.

Minett was a strenuous worker, who expected equal work from his junior colleagues; he appeared stern, but beneath an apparently hard exterior he was warm-hearted and full of fun. His early death is a great loss to British veterinary science.

W. R. WOOLDRIDGE

NEWS and VIEWS

Mr. Cecil Warburton: 100th Birthday

ON February 6, Mr. Cecil Warburton celebrated his hundredth birthday. Mr. Warburton entered Christ's College, Cambridge, in 1876. He became a demonstrator in the School of Agriculture and in the Department of Zoology in the University, and later he was a member of the Quick Laboratory which eventually grew into the Molteno Institute. Mr. Warburton has always had wide interests in general entomology and was for many years honorary zoologist to the Royal Horticultural Society (of which he was elected a life member at the age of ninety-six). He has published papers, etc., on spiders, and wrote the section on Arachnidæ in the "Cambridge Natural History" (Macmillan). Perhaps his best-known scientific work is on the ticks, in collaboration with the late Prof. G. H. F. Nuttall, which led to the production of the standard monograph on this economically important group of animals. For many years now, Mr. Warburton has been a living confutation of the gerontologists, for he has maintained in almost legendary degree his activity of body and of mind—at least he still plays bridge and chess (at which many years ago he represented the University of Cambridge), he is still a dangerous opponent at croquet, and solves *The Times* crossword puzzle each day. At the luncheon given in his honour on the eve of his birthday by his old College, he responded with a lively speech; he was also entertained at luncheon on his birthday by his colleagues at the Molteno Institute of Parasitology.

Geology at Belfast: Prof. J. K. Charlesworth

ALTHOUGH The Queen's University in Belfast has an ancestry going back more than a hundred years, its chair of geology was founded only in 1921. The first occupant, Prof. J. K. Charlesworth, this year retires from the service of the University in the proud knowledge that the task of creating a department almost from its foundations is visibly fulfilled in the newly completed building that forms such an adornment to the University's post-war fabric—though it must be a source of keen regret to him that he has been able to occupy his new rooms for so short a time. After graduating at Leeds under P. F. Kendall, Prof. Charlesworth carried out research and obtained his doctorate at Breslau. He finally moved to Belfast from a senior lectureship at Manchester. His academic interests have been mainly in Pleistocene geology, especially in the history of the Ice Age in Britain; and his work has achieved world-wide distinction for the manner in which he has elucidated late-Glacial changes and described the deposits of the Newer Drift in England and Wales, the recession of the ice in southern Scotland, and the intricacies of successive glaciations in Ireland. These contributions will shortly be rounded off with an elaborate analysis of the glaciation of the Scottish Highlands. In ancillary studies he has discussed the origin of the Irish Sea and of the Irish fauna and flora. He has, however, never been narrowly content with specialist interests, but has used his position to popularize geology as a cultural subject, not least through his recently published book on the geological history of Ireland.

Dr. Alwyn Williams

PROF. CHARLESWORTH is to be succeeded by Dr. Alwyn Williams, a graduate and former Fellow of the University of Wales. While at Aberystwyth, he elucidated the complex structures of the classical Llandeilo district, and began his studies in Lower Palæozoic fossils. Thereafter he spent a year at the Sedgwick Museum, Cambridge, with Prof. W. B. R. King. In 1948 he went with a Commonwealth fellowship to the United States National Museum, Washington, where he worked with Dr. G. A. Cooper on fossil brachiopods, a group in which his main interest lies. Some of his researches on the morphology and taxonomy of protrematous forms have been the subjects of monographs issued by the American Geological Society. Since 1950 he has been lecturer in geology in the University of Glasgow, and has extended his work on Lower Palæozoic rocks from Wales to the Southern Uplands. The wide outcrop of similar rocks running south and south-west from Belfast will give him further opportunities of applying his special knowledge when he takes up his appointment in Ireland.

Physics in the National Physical Laboratory: Dr. Ezer Griffiths, O.B.E., F.R.S.

DR. EZER GRIFFITHS recently retired on his sixty-fifth birthday from his position as a senior principal scientific officer in the Physics Division of the National Physical Laboratory. Appointed shortly before the First World War, Dr. Griffiths had already done outstanding postgraduate research work at University College, Cardiff, which had culminated in two papers (*Phil. Trans. Roy. Soc.*) on the heat capacities of metals, written jointly with Principal E. H. Griffiths. These early interests have been maintained, for Dr. Griffiths has been in charge of the work on heat

during most of his time at the National Physical Laboratory. By his investigations into the thermal properties of materials and contributions to the science of refrigeration, he has established an international reputation. Twice he went to the Antipodes in charge of scientific investigations: first to study the incidence of brownheart in apples during shipment from Australia, and later to make a survey of the transport of New Zealand lamb. Dr. Griffiths's scientific publications have included three books, "Methods of Measuring Temperature", "Pyrometers" and "Refrigeration Principles and Practice", and about a hundred papers, of which for a joint one dealing with the fundamentals of evaporation he was awarded the Moulton Medal of the Institution of Chemical Engineers. Dr. Griffiths has held offices in many scientific societies, and is still serving as president of the Institut International du Froid. He has been succeeded at the National Physical Laboratory by Dr. R. W. Powell, who has been a member of the Heat Section since 1924.

British Association Secretaryship: Sir George Allen, C.B.E.

Sir George Allen, formerly vice-chancellor of the University of Malaya, has been appointed secretary to the British Association for the Advancement of Science in succession to Mr. D. N. Lowe. Sir George was born in Donegal and educated at the Methodist College and The Queen's University, Belfast. At the University he graduated in medicine. After service with the R.A.M.C. in East Africa during 1917–20, he worked for six years as bacteriologist in the Medical Research Laboratory in Nairobi. He then returned to England for postgraduate work in pathology at Oxford and in London hospitals. In 1928 he was appointed bacteriologist in the Institute for Medical Research at Kuala Lumpur. Shortly afterwards he became principal of the King Edward VII College of Medicine in Singapore; he was also president of Raffles College in Singapore. He assisted the Commission on University Education in Malaya to prepare plans for the creation of a University by the fusion of these institutions, and was the natural choice as first vice-chancellor when the new University was established in 1949. In the three years of his vice-chancellorship Sir George Allen succeeded, with tact and administrative skill, in blending two independent institutions into a thriving entity which is now playing an increasingly important part in the life of South-East Asia. He brings to his new work in the British Association a scientific and medical background, an informed sympathy for experimental and field research and wide experience in education and administration.

Element 99

With the ever-increasing amount of effort being devoted to research in nuclear physics, it is perhaps no longer surprising to learn of the production of yet another artificial element—number 99 in the Periodic System (*The Times*, February 3, quoting a statement from the U.S. Atomic Energy Commission). It is well known that there are at least two routes by which new heavy elements may be formed, namely, by successive neutron capture in lighter elements, followed by beta-decay, and also by the nuclear interactions of 'heavy' ions such as $^{12}C^{6+}$, $^{14}N^{6+}$, $^{16}O^{6+}$, accelerated in cyclotrons and used to bombard suitable targets. Both these methods may have been employed; but only one mass assignment has been made, namely, $A = 247$. The nucleus 99^{247} is understood to decay by alpha-particle emission with a half-life of a few minutes. Although this achievement is not unexpected, it reflects the greatest credit on Prof. G. T. Seaborg, of Berkeley, California, and his collaborators. It will be interesting to learn what name the discoverers will propose for the element. The chemical properties may be predicted with some certainty on the basis of Seaborg's actinide hypothesis, and if such properties are in fact observed, one may refer to the element temporarily as eka-holmium. The rare earth holmium was named after Stockholm. One wonders whether the discoverers of element 99 can find a name for it, based on a place-name, which is anything like so euphonious.

Effect of Germanium on the Transformation of White to Grey Tin

The (normally) slow transition of the white, tetragonal form of tin to the grey, cubic modification at 13·2° C. is well known, as is the fact that inoculation with the grey allotrope accelerates the transformation. It is now shown in a paper by R. R. Rogers and J. F. Fydell, entitled "Effect of Germanium on the Transformation of White to Grey Tin" (Canadian Department of Mines and Technical Surveys, Mines Branch, Technical Paper No. 5; pp. 11. Ottawa: Queen's Printer, 1953; 25 cents), that inoculation with germanium is similarly effective in producing the grey form, the tin and germanium being immersed in a strong aqueous solution of calcium chloride acidified with hydrochloric acid to *p*H 1·5 at a temperature of − 30° C. Whereas the grey variety made its appearance only after 31 days with the 'pure' tin, 2 per cent of germanium caused its appearance after 4 days in the case of cast tin. It is noteworthy that in the case of hot-dipped tin coatings much longer periods are required than in the case of castings. The presence of germanium in the alloy, or in aqueous solution, has a corresponding accelerating effect. The presence of zinc in the tin results in a marked retardation of the change, the zinc-free alloy containing 2 per cent of germanium first showing the grey tin after 0·9 day at − 40° C. as compared with 14 days when 2 per cent of zinc is also present. This effect of germanium is possibly one reason for the well-known difference of different varieties of tin in the rate of transformation, since some tin ores are known to contain small amounts of that element.

Fat from Fungi

If fats are to be produced by the industrial utilization of moulds, cheap carbon sources such as cellulose waste and molasses must be considered. As sucrose is the major constituent of molasses, the first stage in the relevant investigations is to ascertain the behaviour of different moulds towards it. S. Murray, M. Woodbine and T. K. Walker (*J. Exp. Bot.*, **4**, 11, 251; 1953) now report on the growth, development and fat formation of some forty-three strains of ten species of fungi when grown on different sucrose-containing media. The highest three yields of felt were given by *Penicillium javanicum* van Beyma, *P. soppi* Zaleski and *Aspergillus nidulans* Eidam, in that order. The fat content on felt weight was maximal at 34·8 per cent with *P. soppi*, at 28·4 per cent with *Fusarium lini* (i), and at 25·8 per cent with *A. nidulans*; on sugar

utilized it was maximal at 11·4 per cent with *P. soppi*, at 7·9 per cent with *A. nidulans*, and at 5·6 per cent with *F. lini* (I). Other moulds are considered worthy of further trial.

Roman Gallery at the Grosvenor Museum, Chester

As part of a general reorganization of the Grosvenor Museum at Chester, a gallery previously devoted to art has been entirely cased in modern style and now illustrates the Roman army. The collections at Chester are particularly rich in Roman material, and it was decided to illustrate the army, and in particular the legions, with special reference to the Chester fortress. The gallery is a long room of nearly 60 ft., and this has been broken up by creating three bays in cases of the shop-window type. This provides a singularly attractive display and provides very useful storage-room. Fluorescent tubes have been used both for the general and individual case lighting. The attention of the visitor is first attracted to a model of a soldier. Then follow panels dealing with a soldier's pay, Samian pottery, tools and equipment, building materials and other objects, leading to a large diorama of the Chester fortress showing its buildings, defences and its relationship to the local topography. The story continues, and to conclude is a final panel illustrating the defences of the Roman Empire.

Electron Microscopy: Conference in London

THE Joint Commission on Electron Microscopy of the International Council of Scientific Unions is sponsoring an international conference on electron microscopy, to be held in London during July 16–21. The detailed organization is in the hands of a committee comprising the members representing the Electron Microscopy Group of the Institute of Physics and members of the Commission resident in Great Britain. Sessions will be devoted to the following subjects: instruments and associated apparatus; electron optics; the attainment of very high resolution; reflexion methods; metallurgical applications; industrial and chemical applications; fixation and drying methods; microanatomy of cilia, etc.; fibrillar structures; structure of cell walls; internal structure of cells; bacteria; viruses; biological specimen techniques; metallurgical and general specimen techniques; and the effect of electron irradiation on matter. All workers interested in the field may attend the conference; they must register with the joint secretaries before March 1 (fee £2). Papers will be accepted for consideration, and authors should in the first instance make their offers to the secretary of the respective national society of electron microscopy, except that in North America they should send them to Prof. T. F. Anderson, 612 Maloney Building, School of Medicine, University of Pennsylvania, Philadelphia 4, and in countries where there is no national society they should send them to the secretary of the programme committee, Dr. V. E. Cosslett, Cavendish Laboratory, Free School Lane, Cambridge. Notification of all papers should be made not later than March 1. The official languages of the conference will be English, French and German. An exhibition of electron microscopes, ancillary apparatus and books is being arranged. General correspondence relating to the conference should be addressed to the joint secretaries, Dr. C. E. Challice and Mr. F. W. Cuckow, c/o Institute of Physics, 47 Belgrave Square, London, S.W.1.

Third International Congress of Nutrition, Amsterdam

THE Third International Congress of Nutrition will be held in Amsterdam during September 13–18 under the auspices of the International Union of Nutritional Sciences. The programme will include sessions on the following topics: overnutrition and disease; nutrition and liver disease; parenteral nutrition; nutrition and the psyche; and non-nutrient foreign chemical substances in foods (intentional and unintentional additives). Invitations have already been sent by the local Dutch organizing committee to a number of proposed contributors; but nutrition workers in Britain, particularly members of the [British] Nutrition Society, who would like to participate in the discussions are invited to submit a title and a short synopsis (not exceeding two hundred words) of their proposed contribution for consideration. These should reach Dr. G. H. Bourne, honorary secretary of the Nutrition Society, Department of Histology, London Hospital Medical College, Turner Street, London, E.1, by February 28. Further information about the International Union of Nutritional Sciences can be obtained from the secretary-general, Dr. L. J. Harris, Dunn Nutritional Laboratory, University Field Laboratories, Milton Road, Cambridge.

International Union of Geodesy and Geophysics: General Assembly in Rome

THE International Union of Geodesy and Geophysics will be holding its tenth General Assembly in Rome during September 15–29. The constituent International Associations of Geodesy, Meteorology, Hydrology, Oceanography, Vulcanology, Terrestrial Magnetism and Electricity, and Seismology and the Physics of the Earth's Interior, will meet during the period. Delegates attending are nominated by the national adhering organizations of the Union. British scientists wishing to attend or to read or communicate papers may do so only if sponsored by the Royal Society on the recommendation of the British National Committee for Geodesy and Geophysics. Those wishing to submit papers for the scientific meetings should write to the Assistant Secretary of the Royal Society, Burlington House, London, W.1, not later than March 1.

Training of Biologists

THE Institute of Biology is arranging a meeting, to be held during April 21–22, to discuss the training of biologists. There will be four sessions: on the teaching of biology in schools to those intending to specialize; on undergraduate courses at universities; on biological work in technical colleges; and on postgraduate training. It is hoped that the meeting will attract teachers from schools, technical colleges and universities and representatives of employing bodies. Ample time will be allowed for discussion after the invited papers. A programme will be available early in March from the General Secretary, Institute of Biology, Tavistock House South, Tavistock Square, London, W.C.1.

Chemistry Meetings in Eastern Germany

THE Chemical Society of the Eastern Zone of Germany has recently issued details of the meetings it proposes to hold this year. The programme opens with a conference in Berlin during February 23–24 on the place of electricity in chemical industry and

ends at the close of the year with a celebration in Berlin of the 125th anniversary of the *Chemisches Zentralblatt*. Other meetings in Berlin will be one on the manufacture and use of plastics (April 13–14), which will partly be held also in Leipzig, one on dietetics and food chemistry (April 27–28) and another on artificial fertilizers (June 15–16). In Leipzig there will be a symposium on synthetic fibres during March 23–24, followed by the annual general meeting of the Society during October 20–23 and a discussion on the light metals during December 7–8. Finally, a meeting of chemistry *Dozents* will be held in Dresden during May 20–21. Further information regarding these events and the Society in general can be obtained from the Chemische Gesellschaft, Berlin NW7, Unter den Linden 68/70.

Physical Society : Spring Meeting in Dublin

The spring meeting of the Physical Society will be held in the Department of Physics, University College, Dublin, during March 30–April 1, and will take the form of a symposium on "High-Energy Accelerators and Cosmic Rays", organized by Prof. T. E. Nevin. Speakers from the following institutions have been arranged : Atomic Energy Research Establishment, University of Birmingham, Brookhaven National Laboratory (United States), Dublin Institute for Advanced Studies, University of Manchester, Maynooth College, Queen's University, Belfast, and University College, Dublin. The meeting will be open to all. Application forms and further information can be obtained from the Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

Announcements

Prof. A. C. Frazer, professor of pharmacology and therapeutics in the University of Birmingham, has been elected an associate member of the Royal Flemish Academy of Sciences of Belgium.

Lord Cherwell, professor of experimental philosophy in the University of Oxford, has been awarded the Messel Medal for 1954 of the Society of Chemical Industry. This Medal, which is the senior award of the Society, is presented once every two years to one who has secured meritorious distinction in science, literature, industry or public affairs, or who is prominently concerned in the welfare of the Society. Previous recipients include Sir Henry Tizard, Lord Bruce of Melbourne and Lord Waverley.

Dr. N. H. Mackworth, director of the Medical Research Council Unit for Research in Applied Psychology, has been awarded the H. M. Vernon Prize of the National Institute of Industrial Psychology, for his work in directing and developing the studies carried out by his Unit in the field of human skilled performance, and for his personal contribution to a more scientific understanding of the effects of climatic conditions upon human behaviour. This is the first award of the Prize, which was founded by the Institute with a sum of money bequeathed by the late Dr. H. M. Vernon, an investigator of the Industrial Health Research Board and one of the original investigators of the Health of Munition Workers' Committee in 1915. The Prize is to be awarded every second year to the investigator who, being a British subject and under the age of forty-five years, has in the opinion of the Council of the Institute done the most valuable research work in the subject of industrial psychology and physiology.

The Harrison Memorial Prize for 1953 has been awarded by the Chemical Society to Dr. Ronald James Gillespie, lecturer in chemistry in University College, London, for his work on the electrochemistry of strong-acid solvents published during the five years 1949–53. Dr. Gillespie is at present carrying out research on the dielectric properties of polar liquids at Brown University, U.S.A. The Harrison Prize was created in 1922 to commemorate the services of the late Colonel Edward Frank Harrison, formerly deputy controller of the Chemical Warfare Department, for the protection of the British Forces from poison gas during the First World War. It is awarded to the British chemist, less than thirty years of age, who, in the opinion of the Selection Committee, has during the previous five years conducted the most meritorious and promising original investigations in chemistry and published the results.

Prof. John Yudkin, professor of physiology in Queen Elizabeth College, London, has been appointed to the University chair of nutrition tenable at that College. The title of professor of civil engineering in the University of London has been conferred on Mr. J. W. H. King, in respect of the post held by him at Queen Mary College, London. The title of reader in photogrammetry in the University of London has been conferred on Dr. E. A. Miskin, in respect of the post held by him at University College, London.

The Institution of Chemical Engineers is holding a symposium on "Gas Absorption" during April 5–7 in the University of Birmingham. The proceedings will be issued as a special publication (42*s*., or 21*s*. to members) obtainable from the Secretary of the Institution at 56 Victoria Street, London, S.W.1. The registration fee of 21*s*. for the conference (42*s*. to non-members) includes a set of preprints. Application forms for registering and further information can be obtained by writing to "Symposium", Chemical Engineering Department, University, Edgbaston, Birmingham 15.

The eighth specialized course on the design, use and maintenance of electronic instruments used in nuclear physics, radiochemistry and in work with radioisotopes will be held in the Isotope School, Atomic Energy Research Establishment, Harwell, during April 5–9. The course, which is for physicists and electronic engineers holding a degree or equivalent qualification, will be limited to twelve persons. The subjects will be entirely unclassified. The fee for the course is 12 guineas plus 5 guineas for those requiring accommodation. Application forms, to be returned by March 26, can be obtained from the Electronics Division, A.E.R.E., Harwell, near Didcot, Berks.

The United States Office of Naval Research and the University of Pennsylvania are organizing a symposium on "The Origins of Drug Resistance, etc.", to be held in the Hotel Statler, Washington, D.C., during March 25–27. There will be five sessions as follows : origins of drug resistance in micro-organisms ; effects of acridines and resistance to insecticides and herbicides ; origins of tolerance and addiction to drugs, and alcoholism ; resistance factors in infectious agents and cancer cells ; and physiological, chemical and genetic points of view. The symposium is open to all. Further information can be obtained from Dr. M. G. Sevag, Department of Microbiology, School of Medicine, University of Pennsylvania, Philadelphia 4, Pa.

ENGINEERING DIMENSIONAL METROLOGY

SYMPOSIUM AT THE NATIONAL PHYSICAL LABORATORY

THE National Physical Laboratory, Teddington, in co-operation with the Mechanical Engineering Research Laboratory, East Kilbride, recently organized a three-day symposium on engineering dimensional metrology, held at Teddington, during October 21–24, at which forty papers were presented and discussed. Some six countries, in addition to the United Kingdom, were represented by delegates drawn from research organizations and industry. The symposium was opened by Sir Edward Bullard, director of the National Physical Laboratory, who, in welcoming the delegates, commented on the wide field of engineering represented by those present. He spoke of the constant need for proper co-ordination between research and industry, and explained that these symposia at the National Physical Laboratory were intended to maintain and strengthen the bond. In introducing Mr. F. H. Rolt, superintendent of the Metrology Division at the Laboratory, Sir Edward mentioned that Mr. Rolt would shortly be retiring, and referred to this symposium as a fitting 'swan song' for him.

Mr. Rolt's address briefly outlined the history of the National Physical Laboratory, and spoke in some detail of the work of the Metrology Division and its contributions to the scientific and practical applications of measurement in industry. He was followed by the director of the Mechanical Engineering Research Laboratory, Dr. D. G. Sopwith, who described the progress of his Laboratory, which had been founded on a nucleus of sections transferred from Teddington. When completed, this Laboratory should be a fitting counterpart to its parent body in the field of mechanical engineering research.

The first two working sessions were devoted to "Workshop Inspection", under the chairmanship of Mr. S. J. Harley (Coventry Gauge and Tool Co., Ltd.), who was director of jigs, tools and gauges at the Ministry of Supply during the Second World War, and Mr. J. E. Sears, former superintendent of Metrology Division, National Physical Laboratory, respectively. Dr. H. Törnebohm (Aktiebolaget Svenska Kullagerfabriken, Sweden) dealt in his paper with the wear of gauges, and mentioned how improved design, as well as the use of chromium plating and hard-metal gauging faces, can noticeably increase gauge life. Comparisons between gauging and measuring methods were made in a paper by Prof. G. Berndt (Dresden Technical College, Germany), who contended that, unless the form of the work-piece is geometrically correct, the shape of the measuring anvils or gauging surfaces is often of more importance than the choice of the measuring method itself.

An interesting optical method of inspecting profiles of turbine blade sections was the subject of a paper by M. J. Turrettini (Société Genevoise, Switzerland). The instrument described defines the profile of the blade by illuminating it with a thin belt of light, and the magnified image of the profile is then projected on to a viewing-screen. With this method it is even possible to view shrouded sections and, by means of a prism assembly rotated at a suitable frequency, two sections in different planes of the blade can be viewed simultaneously owing to the effect of the persistency of vision. Another special-purpose instrument, described by Mr. C. O. Taylerson and Mr. A. Turner (National Physical Laboratory), is used for the measurement of internal diameters to an accuracy of $\pm$ 0·000 01 in. The measurements are made by a pivoted stylus arm to which are attached two mirrors. Differences in size between the diameter being measured and a slip-gauge reference standard produce angular movements of the mirrors, which are measured by means of an autocollimator with an eyepiece scale calibrated in units equivalent to 0·000 01 in. Other papers dealt with methods developed in France and Germany for the measurement of screw threads, particularly taper screw gauges to the specifications of the American Petroleum Institute.

M. Vercoutère (Compagnie Internationale des Machines Agricoles, France) described how the introduction of statistical quality control has assisted the manufacture of agricultural machinery, not only by revealing trends in production but also by giving the machine operators added information on the quality of their work and thereby stimulating their interest in it. This psychological value of quality control was also emphasized by Dr. B. P. Dudding (General Electric Co., Ltd.) in his paper on statistical techniques. The increasing use of mechanized inspection for such difficult work as turbine blades was the theme of Mr. J. Loxham's paper (Sigma Instrument Co., Ltd.), which described multigauging machines incorporating pneumatic indicating devices. Another paper, this time from France, by M. Chalvet (Ministère de l'Industrie et de l'Énergie), dealt with the application of electronics to workshop inspection. During the ensuing discussion it was mentioned that work is being done on the development of electronic devices for gathering and presenting information at present shown in quality-control charts, and the future use of electronics for supplying information to the machine tool and controlling it during its production cycle is also envisaged.

The building of measuring devices into machine tools so as to assist in the dimensional control of the product was advocated in a paper by M. R. Yribarren (Société d'Application de Métrologie Industrielle, France) in the session devoted to pneumatic gauging. It was stated that the introduction of such methods is being delayed by some hesitancy on the part of the operator to accept them for fear that they would lead to loss of craftsmanship, and also on the part of the machine-tool manufacturer for fear that the provision of a measuring device might be interpreted as an admission of functional inadequacy. Much interest was shown in the papers on pneumatic gauging. One, by Mr. L. Polk (Sheffield Corporation, United States), gave a review of developments in the United States, with particular reference to the flow-type of gauge, while another, by Dr. J. C. Evans and Mr. I. G. Morgan (National Physical Laboratory), illustrated the flexibility of the pneumatic gauging technique from examples developed at Teddington during the past five years and ranging from the continuous measurement of fuse wire to the accurate measurement of internal diameters. A quite different application was dealt with in the paper by Dr. K.

Hild (Physikalisch-Technische Bundesanstalt, Germany), which described the use of a pneumatic indicating device in the proving rings used for calibrating load-measuring devices. This session was under the chairmanship of Dr. H. Barrell, who has succeeded Mr. Rolt as superintendent of the Metrology Division, National Physical Laboratory.

A concurrent session on "Machine Tools" was held with Sir William Stanier (Power Jets, Ltd.) in the chair. Increased accuracy in the product has necessitated improvements in machine tools, and Dr. D. F. Galloway (Production Engineering Research Association) emphasized in his paper the value of dynamic, as well as static, metrological tests on machine tools, and also the desirability of testing these machines under load. An autographic method of recording the pitch errors of lathes under running conditions has been developed during recent years at the National Physical Laboratory and was the subject of a paper by Mr. F. H. Rolt. By analysis of the records produced by this method, the sources of error can be traced and, as the test is a dynamic one, irregularities in pitch due to breakdown of lubricating films can be detected. Other papers in this session dealt with methods employed at the Laboratory for testing the accuracy of jig boring machines, and a special lathe for impressing up to 30,000 threads to the inch on highly polished cylinders was described. From the threaded cylinders produced on this lathe, diffraction gratings are obtained by means of the Merton–N.P.L. process—a replica method which eventually, it is hoped, will provide large gratings of very high quality at a low cost compared with the earlier conventional ruling methods. The electronic counting of the 'moiré' bands produced when two diffraction gratings are suitably superposed may be used in the future as an accurate means of controlling linear displacements in measuring machines and machine tools.

Developments in gear metrology at the Mechanical Engineering Research Laboratory were mentioned by Mr. C. Timms in his paper during the session devoted to "Gear Measurement". Examples were given of the use of autographic recording devices in the measurement of both gears and gear-cutting machines, and the conversion of one measuring machine from manual to fully automatic operation enables the measuring of a gear to be made in one-sixteenth of the previous time. During this session, which was under the chairmanship of Dr. H. E. Merritt (Humber, Ltd.), other papers dealt with measuring techniques associated with modern gear-shaving methods and also recent developments in rolling gear testers.

A session devoted to education ran concurrently with that on gears, and Mr. H. J. Shelley (Ministry of Education) was in the chair. The two papers in this section of the symposium dealt with the teaching of engineering dimensional metrology at university and at technical college level, respectively. Prof. H. Wright-Baker (College of Technology, Manchester) referred to metrology as a means to an end in whichever science it is used, and spoke of its disciplinary value to students in achieving precision in their work; the equipment and scope for teaching engineering metrology at Manchester were referred to in some detail. Mr. V. W. Clack (Wandsworth Technical College), in introducing his paper, mentioned that every year about eight students are being trained as designers to each one that is trained as a production engineer. He based this rather disturbing statement on the examination results, which show that annually about three thousand Higher National Certificates in mechanical engineering are awarded compared with about three hundred and seventy-five in production engineering. Mr. Clack's paper described teaching methods and equipment used at Wandsworth, and contained numerous illustrations of demonstration models of great value for instructional purposes.

Mr. G. A. Whipple (Hilger and Watts, Ltd.) presided at a session on "Small-Scale Metrology" which dealt with problems of measurement associated with the manufacture of watches and small screw threads. Mr. K. J. Hume (National College of Horology) discussed applications of metrology in the horological industry, among which he mentioned the insertion of jewel bearings in a liquid of similar refractive index so as to render possible the inspection of their section by optical projection. The production of very small screw threads down to 1 mm. in diameter and 0·1 mm. pitch, together with the measuring problems associated with this class of work, was dealt with in a paper by Mr. P. R. Brierley (Anglo-Swiss Screw Co., Ltd.).

The subject of "Large-Scale Metrology" provided a contrast to the previous papers, and this session, which was under the chairmanship of Sir Stanley Rawson (Costain John-Brown, Ltd.), illustrated very clearly the difficulties associated with large-scale measurement and also the scope that remains for development in this field. In order to assist the International Organization for Standardization in assigning suitable tolerances to interchangeable parts of large size (greater than 20 in.), investigations are being undertaken in Britain and on the Continent of Europe to assess the accuracy of the industrial measurement of large work-pieces. Two papers were concerned with this work, and in one of them Prof. N. N. Sawin drew largely on the experience of the Skoda Works, Pilsen, to describe in detail the many difficulties encountered in the measurement of large dimensions. An interesting feature was the use being made of wood in the construction of large measuring instruments. When suitably proofed against humidity effects, wood (pine in particular) provides a light stable instrument-frame that is negligibly affected by changes in temperature. The use of wooden-framed instruments was also mentioned in the paper by Mr. T. P. Jolly (English Electric Co., Ltd.), which described measuring methods used in the British heavy electrical industry.

A method evolved in the United States for overcoming the difficulties experienced in manufacturing accurate jigs for aircraft frames was the subject of a paper by Captain O. S. Reading (United States Coast and Geodetic Survey), who paid a tribute to the lead that British optical measuring-instrument manufacturers have given in this field of metrology. How precise measurement contributed to the atomic energy project was revealed in the paper by Mr. V. B. Hessen (Ministry of Supply) on the construction of the atomic pile BEPO at Harwell. Yet another application of large-scale metrology, namely, checking the profiles of large marine propellers, was dealt with in a paper by H. C. Garlick and P. W. Harrison (National Physical Laboratory).

Mr. J. E. Baty (chairman of the Surface Finish Committee of the British Standards Institution) was in the chair for the session on "Surface Finish". The first paper, by M. A. Mirau (Laboratoire Central de l'Armement), dealt with the measurement of surface finish in France, where particular emphasis has been

placed on optical methods of measurement. Besides describing a simplified form of microinterferometer which he has developed, M. Mirau dealt with other optical methods for assessing the bearing area and also the quality of polish of surfaces. The complexity of the practical aspects of surface finish of mating parts was discussed in the paper by Mr. R. E. Reason (Taylor, Taylor and Hobson, Ltd.), reviewing developments and trends in this field. Mr. D. B. Ebsworth (Bristol Aeroplane Co., Ltd.) described methods employed in the production of fine surfaces to the exacting requirements of the aircraft industry. In this work a fine surface finish is required, not only to minimize hand fitting and the period of running-in, but also to reduce the risk of fatigue failure, which so often starts from minute surface defects on the highly stressed components.

On the morning of October 24 the Metrology Division of the National Physical Laboratory was opened to delegates, who were able to see the measuring equipment and methods employed at the Laboratory and also exhibits of equipment arranged by a number of the authors of papers.

H.M. Stationery Office will publish the proceedings of the conference, and these will contain the texts of the papers and a report of the associated discussions.

T. R. J. Oakley

THE POTATO ROOT EELWORM AND ITS CONTROL

THE Association of Applied Biologists held a symposium on "The Potato Root Eelworm" at the Imperial College of Science and Technology, London, on January 8, which was well attended and presented a wealth of detailed work, including a demonstration of economic control under certain conditions; some hope for the production of potatoes resistant to the eelworm was also raised. The chairman, Dr. I. Thomas, outlined the magnitude of the problem. Although it is seventy-three years since eelworm cysts were found on potato roots, it was not until 1913 that severe disease was reported from Scotland and Rostock, and the organism was afterwards named *Heterodera rostochiensis*. Since that time, the disease has spread to many parts of the world, half a million acres of arable land being affected in England alone during 1949. About 150,000 acres of potatoes are attacked annually, one-third seriously, giving an overall loss of some 200,000 tons of potatoes worth £2,000,000. In advisory work alone, questions of potato root eelworm absorb a major share of the activities of 80–100 workers who spend about 40 per cent of their time on nematological problems. This last statement by Dr. Thomas seemed, more than any other, to impress members of the conference with the serious nature of the problem.

The morning session was devoted to papers on the hatching of eggs from cysts, and on progress in breeding potatoes resistant to the eelworm. It is vital, in any experimental work with potato root eelworm, to know how many of the contents of the resistant, 'dormant' cyst are still potentially active, and this can be measured by treating the cysts with 'potato root diffusate'—the drainage from potatoes grown in sand culture. Eggs within the cyst hatch into larval eelworms under the stimulus of this liquid, just as they would when potatoes are grown on eelworm-infested land. Dr. D. W. Fenwick gave the results of his extensive studies of this laboratory measurement. When the numbers of larvæ emerging from the cyst are plotted against the logarithm of time in days, a symmetrical sigmoid curve is obtained. Application of probit technique gives a linear relation. Dr. Fenwick then proceeded to show that, since the total number of larvæ emerging is twice the number obtained at the point of inflexion of the sigmoidal curve, much time and space can be saved in laboratory determinations, for numbers only need to be estimated for a time sufficient to establish the point of inflexion. The slope of the probit line is a measure of the susceptibility of cyst contents to root diffusate. Practical findings checked by these theoretical considerations include several important items: temperatures between 10° and 25° C. have little effect on the total hatch, although the rate of hatching increases with rise in temperature; hatching is virtually inhibited at 30° C.; pre-soaking of the cysts in water hastens hatching; *p*H of the root diffusate has no effect between 3·0 and 8·0; sunlight almost inhibits hatching; hatching in a given sample is proportional to the logarithm of the concentration of the diffusate; and since the activities of root diffusate are inhibited in steam-sterilized soil for some weeks, its action appears to be linked with the microflora.

Mr. T. G. Onions spoke on the pattern of hatching from the cyst. He has subjected cysts to the action of root diffusate for a period, and then sectioned them for microscopic examination, to see where the empty, hatched eggs lie. He found most near the vulval end of the cyst, and obtained more from the periphery than from the middle. It was thought that this pattern of hatching might reflect a gradient of oxygen tension.

It would be a great advance in control if potatoes could be bred with resistance to the potato root eelworm. Mr. F. G. W. Jones reviewed the possibilities and progress of this approach. Resistance to this particular eelworm is found in *Solanum ballsii* (= *vernii*) and also in *Solanum andigenum*, which may be no more than a variant of *S. tuberosum*. German workers are investigating the possibilities of introducing resistance through crossing potatoes with *S. ballsii*, and Dutch and British workers are using *S. andigenum* as the resistant parent. The mechanism seems to be that of a dominant gene responsible for resistance, with tetrasomic inheritance giving the possibility of all degrees of resistance and susceptibility. Practical degrees of resistance as yet attained are rather low; but it might be useful to approach the problem of resistance through some contributory issue. Crosses between *S. stenotomum* and *S. vernii*, for example, have low cyst-hatching stimulus which may add, in practice, to their resistance. Another possible line of approach would be to combine high cyst-hatching stimulus with innate resistance, in order to provide the ideal trap crop, and thereby reduce the effective eelworm population.

The afternoon session on direct control opened with a paper by Dr. B. G. Peters on "Laboratory and Pot Tests of Nematicides". These tests are a first stage in assessment of the value of any material for such control. A certain amount of knowledge can be obtained quickly by dispersing a toxicant under test in water and inoculating it with the vinegar eelworm in a special double-flask culture apparatus. Dr. Peters also described the necessary controls and measurements to obtain the maximum

information from pot experiments—to make allowance for natural death, variations in eelworm population, and other factors. He has, indeed, reduced the technique of such tests to a process as exact as possible, and gave examples of their use with D.D. mixture (dichloropropane–dichloropropylene), ethylene dibromide and other materials. A typical useful practical result from pot experiments is that a single injection with D.D. gave a percentage kill of larvæ superior to that with two or three consecutive injections.

Dr. J. Grainger described an economic field control with D.D. on first-early 'Epicure' potato crops in Ayrshire. Increases in yield in numerous experiments since 1947 have been worth about twice the cost of treatment, whether applied at 200 lb. or 400 lb. an acre. Later-lifted crops do not command such high prices a ton as first-earlies, and the yield increase only equals the cost of treatment. Evidence was given for the belief that D.D. has a three-fold action: it can diminish the number of larvæ within cysts; it can diminish the number of full eggs in the cyst in the absence of potatoes; and it can stimulate growth of the potato crop directly. Long-term experiments on possible control of potato root eelworm on main-crops grown in a seven-year rotation were described. They are designed to make the best use of the three-fold action, which also supplies the reason for treating first- and second-early crops as long as possible before the potatoes are planted. Dr. Grainger also briefly described his 'Auchincruive' soil injectors for the application of D.D.; these are now in commercial production. Several results indicated that, for equal quantities an acre, the performance of D.D. was superior when injected as 'spots' at 15-in. centres rather than in continuous traces 12 in. apart. Other materials showing sufficient promise to be investigated on a field scale are ethylene dibromide and inorganic compounds of mercury. These both appear to lessen the build-up of the eelworm population when potatoes are grown, and mercury compounds would be much cheaper than D.D. if they could be mixed finely enough with the soil.

An interesting study on possible control was described by Mr. L. N. Staniland. Phenols, cresols and xylenols and their chlorinated forms give some control of potato root eelworm; but their performance is greatly improved by 'solubilization' with detergents, preferably of the long-chain alkyl sulphate type. They are used as soil drenches at 1 gallon/sq. ft., and at present are quite uneconomic for field application. In the glasshouse, their use is cheaper than steam sterilization, but dearer than D.D. There is, moreover, a danger of tainting the crop. In spite of all these present economic handicaps, however, Mr. Staniland described ways in which performance could possibly be improved. Lower concentrations with more detergent, the introduction of small amounts of iodine, and the performance of different chlorinated compounds are all under test, and Mr. Staniland's audience felt that whether the study ultimately developed economically or not, it would be a sound contribution to the problem.

Prof. H. W. Miles opened the discussion on the morning session of the conference. He said that eelworm study was somewhat neglected in the past, and that the approach to the problem first arose from the farmer. Host–parasite relations are most important for a correct understanding of the problem, and laboratory work is beginning to equal that devoted to the practical approach. Discussion during the afternoon session was initiated by Dr. W. Heeley, who thanked the Association for the opportunities afforded by the symposium, and summarized the economic considerations of direct control arising from the lectures. The use of D.D., he said, comes nearest to practical control at present. It has been suggested that its action might in practice be indirect, putting host and parasite somewhat out of phase. Interesting matters arising from the general discussion are that the breakdown of cysts is slower in peat soils than in loam (Dr. Fenwick), and that potato root eelworm has been found in Peru, one of the native homes of the resistant *Solanum* species. These species are, however, less resistant to the Peruvian strain than to the European eelworm (Dr. C. Ellenby). The question was also raised as to whether a seven-year rotation would itself control infestation of potato root eelworm in practice. Dr. Grainger maintained that the period is not long enough, and certainly not in west Scotland. Infestations capable of causing disease can persist there for 20–25 years in the absence of potatoes. Such results are to be expected by calculation from experiments on the rate of natural loss, and have been confirmed by authenticated advisory cases.

THE RUBBER RESEARCH INSTITUTE OF MALAYA: BOTANICAL DIVISION

THE botanical work of the Rubber Research Institute of Malaya, Kuala Lampur, for the years 1949–51, as presented in its report, is by way of being an interim account of the five-year plan begun in 1949. Important new developments and discoveries, relating to the extensive investigations now in progress, are briefly indicated under the headings of breeding and selection, propagation and planting techniques, tapping, physiology, and ecology. The programme on breeding and selection deals with such items as pollination, the large-scale production of improved seedlings, cytogenetical studies of *Hevea*, the examination of criteria for selection in the laboratory and in the field, the selection of individuals and clones based on their vegetative characters, the quality and properties of latex and rubber, and selection for resistance to disease, etc.

Studies of propagation and planting technique have related to such matters as the effectiveness o bud-grafting on to mature root systems, the pre-budding treatment of budwood, the storage of *Hevea* seeds, stock-scion relationships, density of planting and distribution, the effect of selective thinning-out, the value of mixed planting of *Hevea* and other crops, for example, cacao, and methods of new planting and replanting. Work on tapping has been concerned with tapping systems for seedling and budded trees and slaughter tapping experiments. Physiological studies of the nutrition of *Hevea* have been continued, attention being paid to the cause of the chronic defoliation in certain clones and to latex flow in response to tapping. Researches of a more fundamental character on the physiology of latex are also in progress. The effects of various injected substances, for example, copper salts, on the yield and properties of latex, and the stimulation of latex

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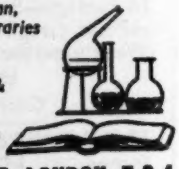

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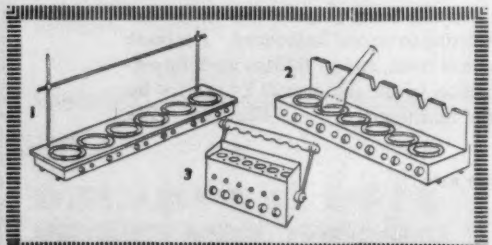

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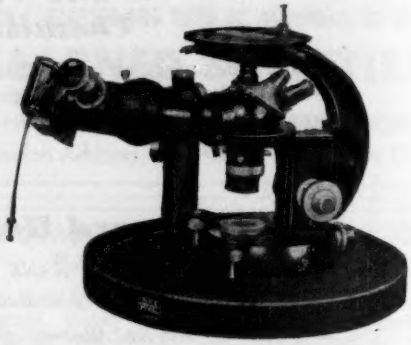

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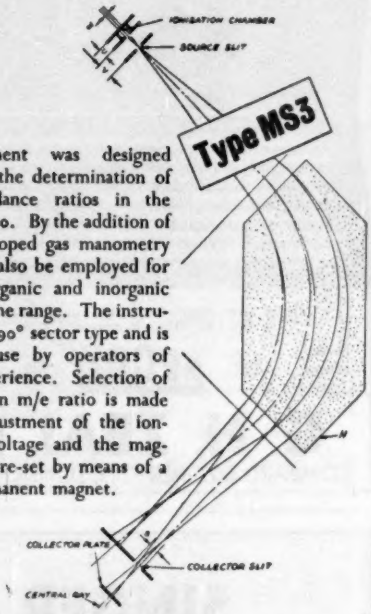

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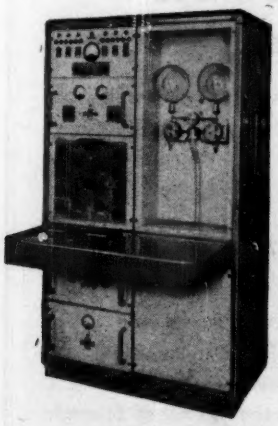

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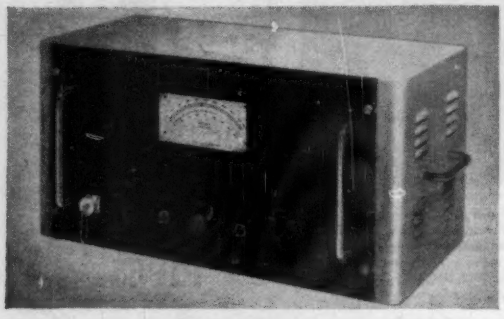

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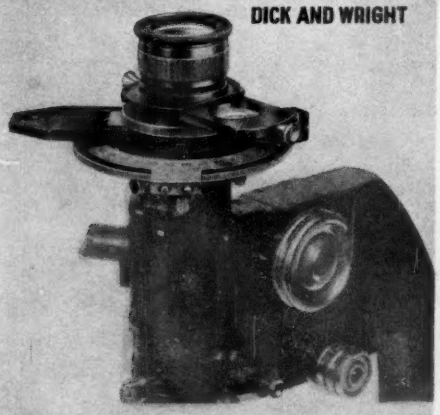

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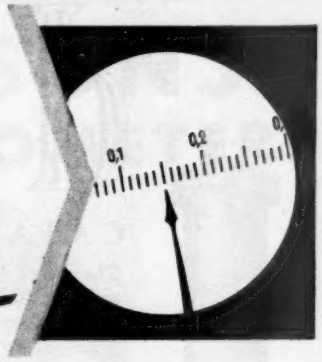

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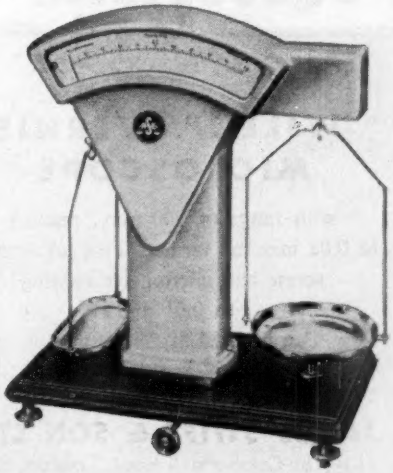

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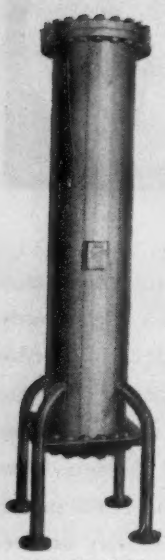

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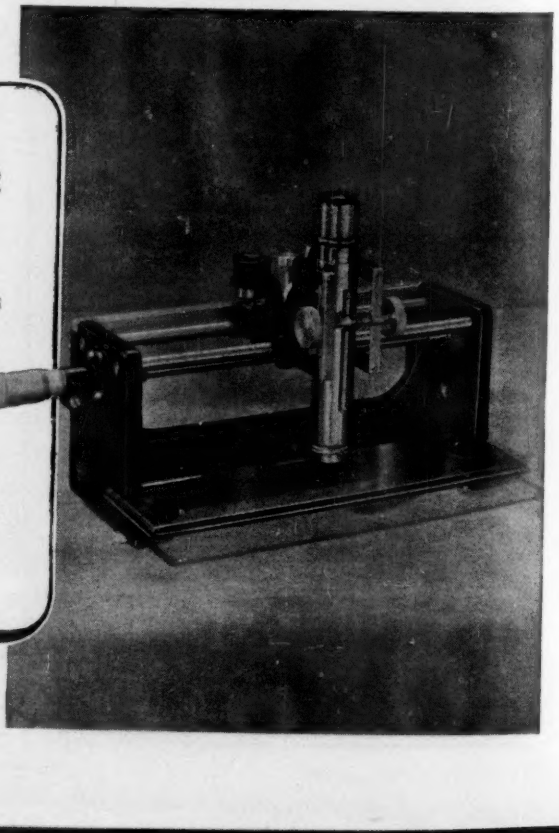

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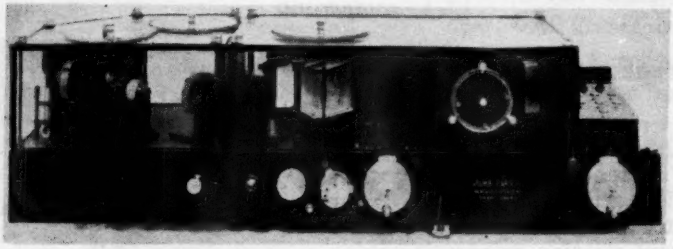

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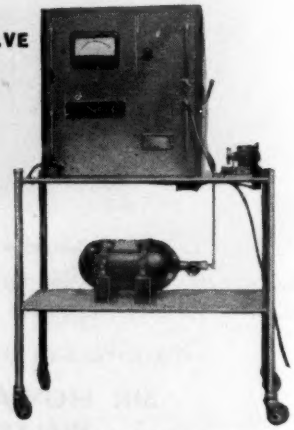

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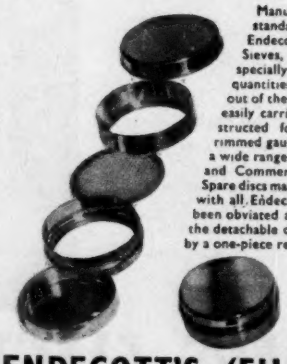

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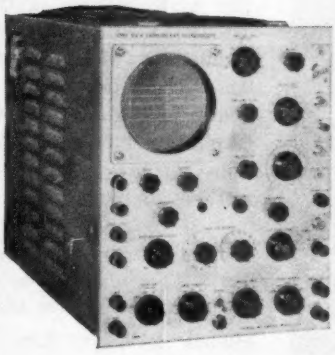

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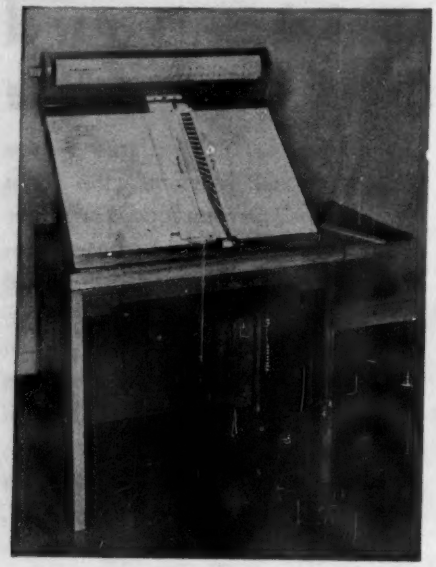

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yield by the application of emulsions of various growth-regulating substances, are also being studied. An unusual, if somewhat contemporary, flavour is introduced by the inclusion in the report of instances of sabotage in the experimental fields by terrorists.

VERY-HIGH-FREQUENCY BROADCASTING IN GREAT BRITAIN

IN its first report last year the Television Advisory Committee made recommendations to the Postmaster-General regarding the future of television broadcasting in Great Britain (see *Nature*, August 22, 1953, p. 337). At that time it was stated that the Committee's next task would be to investigate the introduction of high-frequency sound broadcasting as an additional system to the medium- and long-wave transmissions already used by the B.B.C. for its programmes, and now the Committee has published, as its second report*, its recommendations on this score.

The problem before the Committee and its Technical Sub-Committee is that the existing medium- and long-wave services are barely adequate for supplying the general and regional programmes, that they allow no scope for expansion and that, in fact, they are threatened with progressive deterioration owing to the increased interference from Continental stations, mainly those not bound by the Copenhagen Broadcasting Agreement. It is for the most part accepted that the general plan for tackling this problem is to utilize Band II of the frequency spectrum, namely, the very-high-frequency band of 88–100 Mc./s. (3·4–3 m.) that has been allocated by international agreement to Great Britain for sound broadcasting; because the top part of this band is already used by Civil and other services, this in practice reduces the band to the range 88–95 Mc./s. For most broadcasting, such as the existing B.B.C. programmes (including the sound channel of television), the audio-frequencies are impressed on the carrier wave by the method of amplitude modulation; but very-high-frequency waves do offer the practical alternative of frequency modulation, and the Technical Sub-Committee has gone to great lengths to decide which form of modulation to use. This is a problem of many facets, but the main feature that one must assume is that most receivers will have comparatively poor aerials and that most reception areas will be partly screened and subject to a not inconsiderable amount of electrical interference (for the most part amplitude-modulated). For a service comparable with the sound programmes received on long- and medium-waves, the median value of an amplitude-modulated signal at 90 Mc./s. would need to be 1·5 mV./m. generally and 5 mV./m. in large towns; for the same grade of service on frequency-modulation, the signals need only be 0·25 and 0·8 mV./m., respectively. An interesting point noted in the report is that the signal-to-noise ratio of the sound received in conjunction with television is extremely poor, the amplitude-modulated signals at 45 Mc./s. (at which frequency the standard dipole is twice as efficient as one designed for 90 Mc./s.) being about 0·1 and 0·35 mV./m. for the two types of locality; but from a psychological point of view, the associated visual picture masks the poor signal-strength of the sound.

There are, in fact, three possible types of very-high-frequency broadcasting: frequency-modulation at ± 75 kc./s. deviation, requiring a channel separation of 200 kc./s.; narrow-band amplitude-modulation (channel separation 15 kc./s.); and wide-band amplitude modulation (channel separation 200 kc./s.). For each of these systems to cover 97 per cent of the population of the United Kingdom with three national programmes, the frequency-modulation needs to transmit a total of 760 kW. from 77 transmitters (theoretically 25 per programme, but two extra are needed for Welsh programmes), while the two amplitude-modulation systems require 2,800 kW. from 108 transmitters; the corresponding capital outlays are estimated at £3·5 million and £9 million, respectively, and the annual costs at £800,000 and £2 million. These figures assume a common mast and aerial system for the radiation of three programmes in each area. But the figures for amplitude-modulation are worsened even further if the transmissions in any one area were restricted to a single 600-kc./s. band; for then, due to filtering difficulties, it would be necessary to use three separate, widely spaced masts, or increase the power considerably in a single mast, and in either case the capital and annual costs would be very much increased for such an installation, perhaps as much as doubled.

The report devotes considerable space to the question of receivers, because obviously the introduction of very high frequencies would entail the production of entirely new sets or the adaptation of existing ones, and this is a matter of very great financial importance both to the radio industry and to the public. Though narrow-band amplitude modulation appears on the surface to offer certain advantages, there are in fact considerable difficulties, the principal ones being that oscillator drift in the receiver must be held to the fine limits of 2 kc./s., and it would be very difficult to allocate frequencies which would entail freedom from certain types of interference and also the propagation of interference in the 41–68 Mc./s. band from the receiver oscillator. Thus the choice really narrows down to wide-band amplitude-modulation or frequency-modulation, and as far as receivers are concerned, whether they be adaptors for existing sets or new sets designed for very-high-frequency reception, there seems little to choose between the two systems. As a matter of interest, although adaptors are discussed fully in the report, it is considered that they will be required for only a limited time and that the market for equipment receiving very-high-frequency radiation will eventually be concerned solely with sets designed exclusively for the new type of radiation. Thus the advantage of frequency-modulation is more or less based on the transmitter point of view, though this is not inconsiderable.

The Committee therefore recommends that very-high-frequency broadcasting using frequency modulation should be established in Great Britain, and that this holds good whether sufficient stations are eventually put up to give a national coverage on three programmes or whether the number is sufficient only to provide a substantial reinforcement of the services now given on the long- and medium-waves. This recommendation is signed by nine of the ten members of the Committee, and the dissenting member, Mr. C. O. Stanley, one of the representatives

* General Post Office: Second Report of the Television Advisory Committee (1952). Pp. 25. (London: H.M.S.O., 1954.) 1s. net.

of the Radio Industry Council, has submitted a minority report which is printed in full after the majority report, together with a point-by-point reply by the other members of the Committee to Mr. Stanley's views.

The main feature of Mr. Stanley's arguments is that he does not accept the assumption that very-high-frequency broadcasting need necessarily be introduced in the first place, and that, if it were, the experience of other countries that have introduced it, most of them using frequency-modulation, is decidedly unfavourable. If the plans for very high frequencies go ahead, then the general public will have to start considering buying a completely new receiver, the cost of which for an amplitude-modulator set would be, on the average, £20 and for an equivalent frequency-modulation one £30. Mr. Stanley thinks that the future for the existing broadcasting systems is not necessarily hopeless and that the Committee's first task should be to investigate what may be done to improve them rather than replace them. The reply of the majority of the Committee is that very-high-frequency broadcasting is an unwelcome but inescapable complication, and that its introduction will probably be spread over at least ten years. During that time existing sets owned by the public will tend to wear out and need replacement, and the higher cost of a frequency-modulation receiver is more than outweighed by the advantages of the system.

As in the case of the report on television, the Committee's terms of reference are for the most part concerned with technical problems; but the expansion of television and the introduction of very-high-frequency broadcasting both involve heavy capital outlay by the Government and the development by industry of a wide range of new products, together with the necessity of the general public to find the money for purchasing these products. These are grave economic factors and will, no doubt, be an important, if not over-riding, consideration in any Government decision on these matters.

HORIZONTAL DISPOSITION OF RHIZOMES

THE diageotropic disposition of the rhizome in bishop's weed (*Aegopodium podograria*) has been attributed by T. A. Bennet-Clark and N. G. Ball (*J. Exp. Bot.*, **2**, 169; 1951) to the action of two hormones working in opposition to one another; both are affected by gravity, and the horizontal position of the rhizome is due to an equilibrium between the effects of the two hormones.

N. G. Ball has now taken the investigation of the mechanism of this intriguing problem—the horizontal disposition of rhizomes—a stage further by examining the effects of several known growth-regulating substances on *Aegopodium* rhizomes (*J. Exp. Bot.*, **4**, 349; 1953). The experimental treatments, which involved the immersing of rhizomes for periods of forty-five minutes in solutions of the growth-regulating substances, were carried out in the absence of visible light, the rhizomes being photographed every hour by infra-red radiation. After immersion in 10^{-4} *M* β-indoleacetic acid the rate of rhizome growth is approximately doubled; but about five hours later it declines to one-third or less of its original value and then gradually recovers. This depression in the growth-rate can, however, be reversed by a second auxin treatment, the inference being that the exhaustion of some substance necessary for growth is not involved. It is suggested that the auxin which first accelerates elongation may later be converted into, or may cause the production of, an inhibitor. Thus, when successive immersions in auxin are repeated every two hours, the inhibition can be partially overcome as long as the treatment is continued. As the immersion of horizontal rhizomes in the growth-regulating substance also causes them to turn up, this is taken as giving support to the hypothesis indicated above; that is, an equilibrium is disturbed.

Thus it would appear that when a rhizome is immersed in a solution of auxin there is some mechanism which causes the auxin to accumulate on the lower side. As this may also be assumed to happen to any auxin produced in the rhizome itself, a probable explanation appears to be that the horizontal position assumed by the rhizome results from the balancing of the excess hormone on the lower side of an opposing one. It is pointed out that if the suggestion that β-indoleacetic acid causes an acceleration of growth followed by an inhibitory effect, or that it may itself be converted into an inhibitor, should prove to be generally valid, it would afford a simple and satisfactory explanation of autotropism. The effects of 2 : 4-dichlorophenoxyacetic acid, ascorbic acid, 2 : 3 : 4-triiodobenzoic acid and 2 : 4-dichloranisole were also investigated.

STRUCTURES OF NATIVE AND MERCERIZED CELLULOSES

By Dr. M. K. SEN and Dr. S. C. ROY
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IN a previous publication, Sen and Woods[1] reported the presence of two new equatorial reflexions in the diffraction pattern of native celluloses of various origins. Continuation of this work with more detailed experimentation has now made it possible to make certain assertions with regard to the origin of one of the reflexions, *Y*. From X-ray photographs taken under various conditions of prevailing humidity, intensity and purity of radiation (including monochromatic radiation) and with different cellulose samples, such as ramie, jute, cotton, viscose and paper, it has been noted that the reflexion occurs in greater or less intensity in almost all ordinarily available cellulosic fibres, native or mercerized. Under conditions of 60–70 per cent relative humidity and 70–75° F. temperature, the sharpness, intensity and dispersion of the diffraction maximum are at least equal to those of certain other equatorial reflexions (Fig. 1). The observations regarding its relative intensity in different samples when compared against Meyer and Mark 101 are summarized in Table 1.

Table 1

Samples	Intensity
1. Defatted white jute	Slightly less than that of 101 reflexion.
2. Commercially degummed ramie	Less than that of 101.
3. Surgical cotton	Less than that of 101.
4. Ordinary rayon	Slightly less than that of 101.
5. Pre-swollen rayon (treating with ethylene diamine, washing and drying)	Slightly less than that of 101.
6. Mercerized ramie	Greater than that of 101.
7. Mercerized jute	Greater than that of 101 (mercerized).

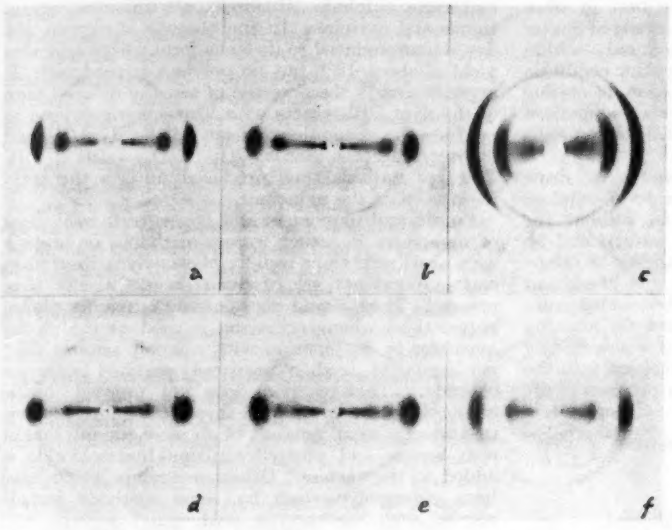

Fig. 1. X-ray photographs with copper $K\alpha$ at 30 kV. and 20 m.amp. (*a*) Native ramie; (*b*) native jute; (*c*) native cotton; (*d*) mercerized ramie; (*e*) mercerized jute; (*f*) viscose

In point of sharpness, reflexion *Y* not only invites comparison with other equatorial spots but in some cases even excels them. Its dispersion across the equator runs parallel with the dispersion of the other reflexions and, in relatively more extensible materials such as mercerized ramie and mercerized jute, becomes reduced on progressive stretching.

The spacing at room condition (60–70 per cent relative humidity and 70–75° F. temperature) corresponding to the reflexion for different samples is shown in Table 2.

Table 2

	Spacing (A.)
Native jute	14·3
" " delignified	13·6
" " alkali-treated (0·2 %)	13·6
" " " (1·0 %)	13·6
" " " (5·0 %)	13·6
" " mercerized without tension	14·0
" " mercerized and stretched (16 % shrinkage allowed)	14·0
" " mercerized and stretched (4 % shrinkage allowed)	14·2
Native ramie	13·6
" " mercerized without tension	14·7
" " mercerized and stretched (16 % shrinkage allowed)	14·4
" " mercerized and stretched (4 % shrinkage allowed)	14·5
Cotton	13·1
Viscose	14·8

It is therefore concluded that the reflexion originates from the cellulose crystallites. The difference in the intensity and the variation in the spacing for different samples should arise from the formation of mixed crystals with other polysaccharides and/or absorption of water, which may be the water of hydration or the structural water.

Attempts were made to fit the new reflexion into the reciprocal lattice nets as obtained from the unit cells due to Meyer and Mark[2], Sauter[3] and Andress[4]. It was found that none of the hitherto accepted unit cells could account for this reflexion. From analysis of our photographs, it has been possible to fit all the reflexions from native and mercerized ramie as ordinarily obtained into two different unit cells the parameters of which are as follows:

	a	*b*	*c*	β
Native cellulose	15·8 A.	10·3 A.	12·5 A.	60°
Mercerized cellulose	16·3 A.	10·3 A.	9·0 A.	64°

The observed and the calculated values of the spacings and the corresponding indices of the planes are shown in Tables 3 and 4.

The cells apply also for cotton, jute and other cellulosic fibres, the only difference being in the slight shift in the 100 plane and hence a small change in the dimensions on account of the inclusion of water or other polysaccharides.

We believe that the Meyer and Mark, as well as Andress, cells for native and mercerized celluloses do not represent the structure of the material under ordinary conditions of temperature and humidity. On the other hand, the cells proposed account for all the reflexions as obtained from flat-film rotation photographs. Furthermore, the theory of the impenetrability of cells of native cellulose by water does not seem tenable, because, as is evident from the changes on moisture absorption in the spacing due to the 100 plane in native cellulose and those due to the 100 and 200 planes in mercerized celluloses (see also Sen and Woods[1], and Mukherjee and Woods[5]), varying amounts of water can remain within the cells. This being so, the current concept of the crystalline and non-crystalline regions perhaps needs revision. The ideas might perhaps be best expressed in terms of accessible and inaccessible regions and perfect and imperfect crystallinities, there being no sharp line of division between the two.

The failure of previous workers to observe the newly found reflexion are ascribed to: (*a*) use of

Table 3. *hkl*, d_{cal} and d_{obs} values (native ramie)

hkl	d_{cal} (A.)	d_{obs} (A.)	*hkl*	d_{cal} (A.)	d_{obs} (A.)
100	13·68	13·70	221	4·29	4·31
			$\bar{3}21$	2·95	2·88
102	5·87	6·01	023	2·96	
202	5·90				
002	5·41	5·43	231	3·14	3·22
303	3·93	3·96	$13\bar{2}$	2·69	2·65
402	3·87		$14\bar{2}$	2·21	2·18
404	2·79	2·65	331	2·87	2·96
606	1·96	1·96	032	2·90	
014	2·62	2·64	341	2·31	2·35
211	6·19	6·15	042	2·33	

Table 4. *hkl*, d_{cal} and d_{obs} values (mercerized ramie)

hkl	d_{cal} (A.)	d_{obs} (A.)	*hkl*	d_{cal} (A.)	d_{obs} (A.)
100	14·65	14·60	$31\bar{2}$	2·52	2·57
200	7·33	7·35	513	2·56	
			613	2·35	2·39
102	4·39	4·42	021	4·34	4·35
202	4·46				
002	4·04	4·03	$\bar{2}21$	3·40	3·41
003	2·70	2·66	$\bar{3}21$	2·92	2·93
404	2·23	2·21	223	2·59	2·58
210	5·97	6·02	023	2·39	2·38
012	3·77	3·78	031	3·16	3·14
412	3·41	3·38	132	2·71	2·62
$\bar{2}12$	2·90	2·91	431	2·62	

large primary beam stop, (*b*) absorption in fibre bundles due to very thick specimens, (*c*) use of Sauter camera capable of recording reflexion only within limited angular range, (*d*) perhaps very dry condition of specimen, the intensity of the reflexion decreasing with the loss of moisture, and (*e*) low collimation ratio in certain cases and therefore lack of sufficient resolution.

Our results at present do not permit us to draw any conclusions concerning the structure of cellulose in a perfectly dry condition (that is, without the chemically combined last trace of water), and so nothing can be said regarding the validity or otherwise of the unit cells due to Meyer and Mark and Andress for perfectly dry fibres. A detailed communication on the various issues and far-reaching implications likely to be involved in this new finding is being published elsewhere. Investigation into the probable space-group symmetry is in progress.

[Sept. 23.

[1] Sen and Woods, *Biochim. Biophys. Acta*, **3**, 510 (1949).
[2] Meyer and Mark, *Ber.*, **61B**, 593 (1928).
[3] Sauter, *Z. physik. Chem.*, **B35**, 83 (1937).
[4] Andress, *Z. physik. Chem.*, **B4**, 190 (1929).
[5] Mukherjee and Woods, *J. Text. Inst.*, **42**, *T*309 (1951).

DYE-SENSITIZED PHOTOPOLYMERIZATION

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FREE radicals, except the most stable ones, will initiate the polymerization of vinyl compounds. The free radicals may be produced by the direct photolysis of the monomers, but this requires light of wave-length well into the ultra-violet spectrum[1]. Light of nearly ultra-violet wave-length (~ 3000 A.) will cause the breakdown of substances such as benzoyl peroxide into free radicals which will initiate polymerization[2]. Irradiation of solutions of acidified ferric salts by light of this wave-length will also produce free radicals capable of initiating the polymerization of vinyl compounds[3].

Attempts have been made to extend the spectral range of the photopolymerization to the visible region by using dyestuffs as photosensitizers[4]. These reactions, which were carried out in the absence of oxygen, gave low quantum yields for the conversion of monomer. I have shown that the quantum yield for the conversion of acrylonitrile to polymer in water using rose bengal as the sensitizer is considerably enhanced if the solution, irradiated with visible light, contains ascorbic acid and if oxygen is present[5]. In the present communication, the results of our experiments for dye-sensitized photopolymerizations of high quantum yield are summarized. The practical implications of this work are treated elsewhere[6].

Acrylonitrile in aqueous solution (7 per cent in monomer concentration and buffered at *p*H 7·0) with fluorescein or one of its halogenated derivatives (eosin, phloxine, erythrosine, rose bengal) as the sensitizer is readily polymerized on irradiation with visible light if oxygen is present and if the solution contains a mild reducing agent. Ascorbic acid and phenylhydrazine hydrochloride are particularly effective as reducing agents, while the photopolymerization proceeds more slowly with hydroxylamine, hydrazine sulphate, thiourea, allylthiourea, glutathione and cysteine. In the absence of oxygen, the dye is photoreduced to its leuco form with a quantum yield of about 10^{-3}, but no polymer is produced. It appears that in the presence of air, the reduced form of the dye, DH_2, reacts with atmospheric oxygen to produce the semiquinone form of the dye DH and hydroxyl radicals, that is, $DH_2 + \frac{1}{2}O_2 \rightarrow DH + OH$. The free radicals thus produced initiate the polymerization of the monomer.

Pure liquid monomers and concentrated solutions of monomers in either water, methanol or acetone were also found to be rapidly photopolymerized when certain combinations of dye-reducing agents were present. Thus, liquid acrylonitrile is readily photopolymerized when acriflavine is used as the photosensitizer in conjunction with a small amount (10^{-4} per cent) of freshly prepared acidified stannous chloride. This reaction does not proceed in the absence of oxygen. Liquid styrene is photopolymerized when a small amount of an alcoholic mixture of rose bengal and phenylhydrazine hydrochloride is added to the system. Other monomers which have been photopolymerized by these methods include acrylic acid, methacrylic acid, vinyl acetate, and methyl methacrylate. Some dyes such as brilliant green and rhodamine *B* were found to be effective, whereas other dyes, such as all the triphenyl methane dyes which we tested, were found to be ineffectual. Azine dyes, particularly pinakryptol green, in trace amounts (10^{-3} per cent) are inhibitors of photopolymerization for the systems described above. It is significant that the azine dyes are also inhibitors for the photoreduction of fluorescein and its halogenated derivatives[6,7].

The choice of the reducing agent to be used in conjunction with a given dye is critical. In general, the reduction potentials of the dye (at a given *p*H) should be more negative than that of the reducing agent, so that the dye is not decolorized in the dark. Furthermore, the reduction potential of the dye should be within about two electron volts of that of the reducing agents, since this is a necessary condition for the photoreduction of the dye by visible light[7]. The concentration of oxygen present is also critical. Oxygen can participate in the photosensitized destruction of the reducing agent and will, for some monomers, inhibit the growth of the polymer chain. Uri[8] found that the quantum yield for photopolymerization of methyl methacrylate in alcohol sensitized with chlorophyll was considerably enhanced if ascorbic acid is present; but the reaction does not proceed in the presence of oxygen. In some cases it appears that the solvent, for example, acetone, may participate in the reaction and that the semiquinone form of the dye is the active radical for the initiation of the polymerization.

Certain monomers such as *N*-vinyl pyrrolidone and acrylamide are themselves reducing agents. For example, aqueous solutions of acrylamide sensitized with the easily reducible dye riboflavine are readily photosensitized, no additional reducing agent being added. A 10 per cent aqueous solution of acrylamide containing 0·005 per cent riboflavine was irradiated with light from a 500-W. tungsten lamp, the sample being 45 in. from the lamp, and a blue Corning glass filter passing light mainly of wave-length 4360 A. was interposed between the lamp and the solution. By the use of a calibrated thermopile, it was determined that $2{\cdot}8 \times 10^{-10}$ einsteins were absorbed by 1 ml. of the solution per sec. After an induction

period of 5 min., the monomer is converted into polymer at a constant rate and the viscosity rises very sharply, the solution becoming a stiff gel after irradiation for 30 min. The quantum yield of monomer conversion is 4,250. Much higher quantum yields are obtained using high concentrations of monomer and decreasing somewhat the oxygen concentration, although complete removal of oxygen inhibits the reaction. The molecular weight of the polymer produced after irradiation for 15 min. was found by light scattering (after carefully washing the methanol-precipitated polymer and redissolving in water) to be 8·32 millions. This extraordinarily high molecular weight may be attributed in part to the fact that the polymerization was carried out at room temperature rather than at elevated temperatures where most polymerizations (thermally initiated) are carried out.

A 10 per cent solution of acrylamide sensitized with riboflavine was irradiated with a single burst of light of millisecond duration from a large commercial photographic flash lamp. After an induction period of one hour, the viscosity of the solution gradually rises and the system becomes a stiff gel on standing 24 hr. in the dark. More concentrated solutions of monomer also show an induction period, and the solution is rapidly transformed into a hard, clear plastic. The sample becomes very hot due to the exothermic character of the polymerization. Solutions from which oxygen had been rigorously removed do not exhibit polymerization after irradiation by the flash until the vessel is opened to the atmosphere. It is clear that free radicals are not produced directly by visible light, but rather are produced by the dark reaction between the reduced dye and oxygen.

[1] See, for example, Oster, G., and Mark, H., *J. Opt. Soc. Amer.*, **43**, 283 (1953).

[2] See, for example, Klatte, F., and Muller, H., U.S. Pat. 1,920,403 (1933). Christ, R. E., *Chem. and Indust.*, **59**, 267 (1940). Burnett, G. M., and Melville, H. W., *Proc. Roy. Soc.*, A, **189**, 481 (1947).

[3] Owens, J. S., U.S. Pat. 2,344,785 (1944). Baxendale, J. H., Evans, M. G., and Park, G. S., *Trans. Farad. Soc.*, **42**, 155 (1946). Evans, M. G., Santappa, M., and Uri, N., *J. Polymer Sci.*, **7**, 243 (1951).

[4] Bamford, C. H., and Dewar, M. J. S., Symp. Soc. Dyers and Colourists (1949), 110. Whyte, R. B., and Melville, H. W., *ibid.*, 119.

[5] Oster, B., paper presented before the 122nd Annual Meeting of the Amer. Chem. Soc., Atlantic City, September 15, 1952.

[6] Oster, G., *Photographic Engineering*, **4**, 173 (1953), and forthcoming patent disclosures.

[7] Oster, G., Adelman, A., Schrader, M., and Wotherspoon, N. (unpublished results).

[8] Uri, N., *J. Amer. Chem. Soc.*, **74**, 5808 (1952).

VISUAL PURPLE LEVEL AND THE COURSE OF DARK ADAPTATION

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WHEN we go suddenly from moderate light into darkness, at first we can see nothing; but over the next half-hour visibility greatly improves. Owing largely to the work of Hecht, the improvement has been attributed in the main to two factors: (*a*) the shift of vision from cones to rods; (*b*) the regeneration of visual purple bleached in the light-adapted state. With regard to (*b*), there is no doubt that this occurs after intense illumination, for Tansley[1] followed the process in the rat by extracting the visual purple from the eyes of animals killed at various stages, and Rushton[2] (with Brindley and Hagins) has measured the course of bleaching and regeneration

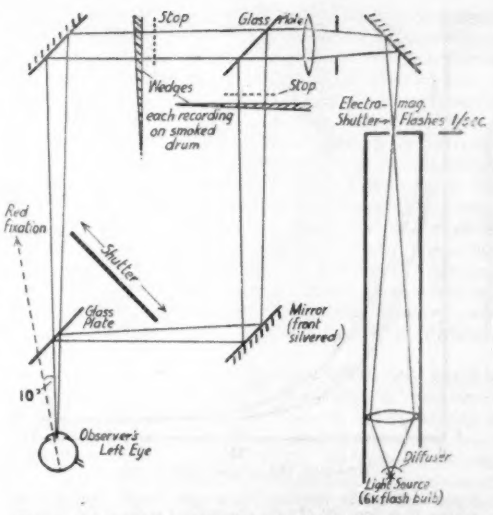

Fig. 1. Adaptometer with alternate light-paths so that two different test flashes may be compared throughout dark adaptation

in the living cat and albino rabbit by an optical method. But as Granit *et al.*[3] have shown, there is a very serious discrepancy in the quantitative correspondence between the change of visibility and the change in visual purple content of the retina; for, light of a brightness which would alter the visibility many hundred-fold (as indicated in the animal by change in the size of the electroretinogram) was found not to have appreciably bleached the visual purple, later extracted and measured. Schouten and Ornstein[4] demonstrated that the effect of glare cannot be explained upon a pure photochemical basis, and Baumgardt[5] has calculated that at moderate illumination extremely little of the visual purple supply of the eye would be broken down. Our own observations have led us in the same direction, and from the evidence now to be presented we conclude that there is no detectable change in the level of visual purple in the hundred-fold increase of sensitivity which follows the extinction of an ordinary room light.

The observer himself plotted the course of his dark adaptation by moving a wedge in front of his eye so that a flash of light was only just visible (Fig. 1). The wedge movement was recorded upon a very slow smoked drum. By means of alternate optical pathways from flash to eye, each with its own recording wedges, two dark adaptation curves could be traced at a single run by arranging that the flashes came now by one path, now by the other. In this way the effects of colour, field-size, duration and retinal location of the flash could be easily compared at a given stage of adaptation. A red fixation point was used and the flashes fell at about 1 per sec., some 10° on the temporal aspect of the retina (that is, far from the blind spot). The observer first spent half an hour in the dark, then he had 20 sec. close in front of an opal glass of luminance 300 ft. L. for light adaptation; the adaptation curves were then traced in the dark by setting the wedges alternately.

The results of one typical experiment are shown in Fig. 2; they were adjusted to coincide for full dark adaptation. The test flash was green; but the same results are obtained with any colour from

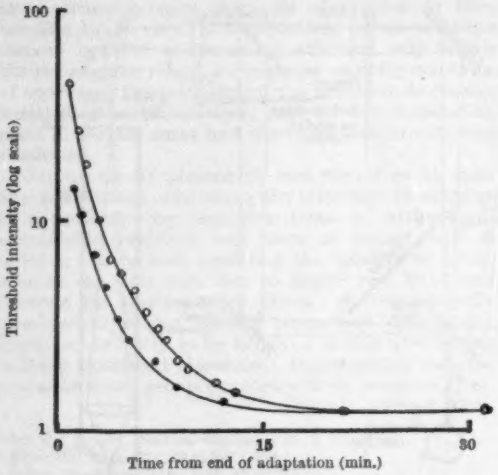

Fig. 2. Threshold intensity of a just visible flash plotted against time from end of light adaptation (300 ft. L. for 20 sec.). Circles: 2° field, $\frac{1}{2}$ sec. flash. Dots: 3° field, 7 m.sec. flash. Adjusted to coincide at full adaptation

violet to yellow-green. Orange and red, on the other hand, give an adaptation which is rapid and slight, due no doubt to cones being involved. We conclude that the curves of Fig. 2 are entirely due to rods.

Now the regeneration of visual purple must affect these two curves equally; hence the superior dark adaptation of the upper one is clearly due to other causes. But we can exclude regeneration as a cause even of the lower one. For if we assume that visual purple in the eye bleaches as it does in solution with a quantum efficiency of 1 (Dartnall *et al.*)[6], then 20 sec. at 300 ft. L. with pupil diameter 3 mm. will bleach about 2 per cent of the visual purple present. It is not easy to escape this conclusion by supposing that in the living eye visual purple is bleached much faster than *in vitro*, for (unpublished) observations by Rushton and Hagins on the living albino rabbit show the bleaching-rate to be about the same as in solution (or a little slower). Thus in the experiment of Fig. 2, the visual purple could not increase its concentration appreciably throughout dark adaptation since at the outset it was 98 per cent of the maximum.

We must therefore turn to consider what factors could account for the increased visibility during dark adaptation which certainly occurred. These may conveniently be classified in four categories: increase in (i) the fraction of light incident upon the cornea which reaches the retina; (ii) the fraction of light incident upon the retina absorbed by the visual purple; (iii) the summation time and summation area; (iv) the quantum sensitivity.

The only likely variable under (i) is size of pupil. This could not affect our records since the light flash was focused upon the centre of the pupil in a 1·2-mm. pencil.

(ii) As we have seen, this effect cannot contribute.

(iii) An optic nerve fibre will only discharge if the receptors connected to it have caught a certain number, N, of quanta within a certain summation time. The longer the summation time and the wider the summation area, the more likely that N quanta will be caught from a flash which is extended in space and time (as in the circles, Fig. 2). But if the flash were highly restricted in space and time (dots, Fig. 2), no increase in sensitivity would appear from cause (iii). The difference in the curves of Fig. 2 may thus be regarded as expressing the increase in summation area and time which occurs as dark adaptation proceeds, as already found by Craik and Vernon[7]. It is left unsettled whether this is a gradual increase in the size of receptive field of single nerve fibres as found in the cat by Kuffler[8], or a change of activity from small to large fibres as suggested by Pirenne and Denton[9]. In any event, it is highly efficient, since 'information' is not lost, but by exchanging sensitivity for precision, the maximum discrimination can be secured at each luminance.

(iv) The quantum sensitivity is the inverse of N, the number of quanta necessary to excite an optic nerve fibre. Since the lower curve of Fig. 2 is not affected by (i), (ii) or (iii), it must represent simply a change in (iv) during dark adaptation.

We conclude that, in the conditions here considered, by far the chief factor in dark adaptation is an increase in quantum sensitivity of the retina.

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REPRODUCTION IN MARSUPIALS

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RESEARCH on the problems of marsupial reproduction is at present in progress in this department. Several marsupial species are housed in the departmental enclosures; but so far systematic work, here briefly reported, has been limited to the Rottnest Island wallaby (*Setonix brachyurus* Quoy and Gaimard). This animal breeds readily in captivity, and periodical surveys carried out on Rottnest Island indicate no great differences in reproductive processes between the wild population and the departmental colony. Several papers dealing with aspects of reproduction in this animal are at present in course of preparation.

The reproductive system is anatomically similar to those of other macropod marsupials described by Pearson[1]. Our records show that *Setonix* is exclusively monovular; multiple ovulations or births have not been recorded in either wild or captive populations. The animal is polyœstrous, and the recurring œstrous cycles are of approximately twenty-eight days duration. This is the same length as the œstrous cycle in the American polyprotodont marsupial *Didelphis*[2]. In both wild and domestic populations the unfertilized *Setonix* has regular œstrous cycles between late January and the end of October. During the remaining (summer) months there is an anœstrous phase during which ovary and uterus are quiescent.

The significance and cause of the annual anœstrus are not known. Experiments are in progress to

determine whether increased daily illumination is the immediate predetermining stimulus. During the summer, the animal is exposed to periods of extreme drought, and it could be plausibly postulated that the anœstrous period has adaptive significance in preventing the extra water utilization involved in lactation during the dry period. It also has the merit of ensuring that most births take place immediately after anœstrus, the young then being sufficiently developed to leave the pouch when green feed is abundant in the following spring.

We have little information concerning the number and length of the œstrous cycles in other marsupials. Hartman[2] showed *Didelphis* to be polyœstrous, whereas Hill and O'Donoghue[3] consider the Australian polyprotodont, *Dasyurus viverrinus*, to be monœstrous. *Bettongia cuniculus* is polyœstrous, the length of the cycle being unknown, although there may be an anœstrous period in the summer months[4].

In wild populations of *Setonix* there is a burst of sexual activity following the annual anœstrous period, and it is at this time that the majority of young are born. Copulation takes place while the first maturation division is proceeding in the ovarian egg. Ovulation follows in mated animals approximately one day *post-coitum*. In unmated animals ovulation is independent of the stimulus of copulation. Parturition occurs from twenty-four to twenty-eight days after mating, most likely on day twenty-six or twenty-seven. As in the American opossum, gestation is thus shorter than the length of a normal œstrous cycle. In *Didelphis*, as in *Setonix* and most other Australian marsupials, no true allantoic placenta exists at any time during gestation. It is probable that the marsupial yolk-sac placenta, unlike the eutherian (allantoic) placenta, has not assumed pituitary and ovarian functions as a secondary source of hormones. If this is true, it may well mean that the aplacental marsupials are physiologically incapable of retaining young in the uterus for a period greater than the length of the œstrous cycle.

In fertilized animals, maturation of an ovarian follicle continues during pregnancy as in the normal non-pregnant animal. Parturition is closely followed by œstrus and ovulation, the corpus luteum of post-partum ovulation becoming the corpus luteum of lactation. This corpus luteum is maintained during the ensuing five or six months, while the young is suckled in the pouch, and retrogresses thereafter. During at least the first half of this time a lactation anœstrus occurs. Although females normally copulate at post-partum ovulation, birth of a second young does not occur while the mother is feeding an embryo in the pouch. However, females segregated from males immediately after post-parturition copulation give birth to a second young if lactation is interrupted by removal of the pouch young. This second fœtus could be explained either by delayed implantation or by the prolonged storage of sperm. Delayed implantation in rodents is known to be due to the feeding of large litters by the pregnant mother. Although the uteri of lactating *Setonix* present no external differences from those of the non-pregnant animal, these were subjected to thorough search in serial section. In several lactating animals which had copulated at post-partum heat a small unimplanted blastocyst 0·3 mm. in diameter was found in the uterus; blastocysts have also been recovered whole by flushing the uterus with saline.

The unimplanted blastocysts of lactating *Setonix* can certainly proceed to normal development after a quiescent period of four months; some evidence indicates that they may remain viable for periods of about eight months in this state of suspended animation. It appears, therefore, that we have a sufficient explanation of delayed parturition in terms of 'stored unimplanted blastocysts'. As an additional confirmation of this conclusion, we destroyed the Fallopian tubes in two females suckling pouch young, so that no new eggs could enter the tract. The suckling young were removed from both. Two days later, the uterus of one mother was flushed out and a small blastocyst recovered. Eleven days after the operation the uterus of the second mother was similarly treated, and a large actively dividing embryo recovered.

In all Eutheria investigated, with the possible exception of the bat[5], sperm may have a very short life in the female tract. So it would be surprising if storage of sperm in the marsupial female tract were a reason for delayed parturition. At best, of course, it could only be a cause supplementary to the delayed implantation described above. Nevertheless, careful search was made for sperm in the female tract, and although easy enough to find immediately after copulation, they were never detected at a greater period than a week after insemination.

It is not known how widespread the phenomenon of delayed parturition is in marsupials, although many (often verbal) reports are known. A case is cited by Wood Jones[6] in which a female red kangaroo suckled a pouch young for about a year after the death of the male parent. This female, in captivity in Philadelphia Zoo, could not possibly have mated after the death of the male kangaroo, yet gave birth to another young at about the time the pouch-life of the first young ended. In this, as in other cases of delayed parturition in marsupials, it is interesting to note that the female was lactating during the delayed period. Flynn[4] recorded several specimens of the macropod marsupial *Bettongia cuniculus* carrying pouch young of widely different ages to have a small blastocyst in one or other uterus. Limited by lack of controlled breeding experiments, he concluded these blastocysts to be stages in normal pregnancy. He was therefore forced to suggest a very short (six weeks) pouch-life of the embryo, since only one young occupies the pouch at one time. In all other macropod marsupials for which information is available, the pouch-life exceeds four months.

I am indebted to Prof. H. Waring for assistance in the field and with surgery, to Mr. A. J. Fraser for making sea transport available and in his capacity of chief warden of fauna in Western Australia, to Miss Nathan for general and histological assistance, and to Mr. Jeapes for animal maintenance. The animal compounds were paid for from an Australian Commonwealth Research grant which also met some of the expenses.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Fluorine in Tea and Caries in Rats

Fluoridation of communal water supplies is expanding rapidly in the United States, and it has been recommended that water supplies in Britain should also be treated[1]. Nevertheless, it is generally recognized that Britons already take appreciable amounts of fluorine in their tea, which is rich in this element. Experiments detailed in this communication deal with the effect of tea infusion on dental caries in the rat.

Litter-mate Wistar rats 23 days of age were used in these experiments, which were continued for sixteen consecutive weeks. The cariogenic diets comprised 800 gm. cracked yellow corn, 30 gm. alfalfa meal, 60 gm. linseed meal, 250 gm. sucrose, 80 gm. corn oil, 50 gm. active dry yeast and 10 gm. sodium chloride; 1 gm. fresh liver was added to this diet once weekly. In the control group, water with 0·02 p.p.m. of fluorine was allowed *ad libitum*. In the experimental group, similar water was used to make strong infusions of a commercial brand of tea (Standard Brands Instant Tenderleaf Tea (orange pekoe and pekoe black)). Such infusions, checked for fluorine concentration by the method of McClendon and Foster[2], would be considered too strong for humans, who are much more sensitive to fluorine than rats as measured by dental fluorosis. The small content of dextrimaltose in the tea was duplicated in the drinking water of the controls. Repeated periodical comparisons proved that those rats allowed only tea infusions consumed quantities similar to those drinking water. At the end of the experimental period, the animals were weighed and X-ray examinations were made of the skeleton and jaw bones for comparison of calcification and dental caries.

Slightly more than half the original thirty animals in each group were dead at the end of the experiment, leaving eleven pairs of litter-mates for final examination.

Animals in both groups failed to gain weight normally. X-ray examinations showed the skeleton in both groups to be similarly decalcified. Caries of the lower molars with much alveoloclasia was present in both groups with no significant difference (Table 1 and Figs. 1–4).

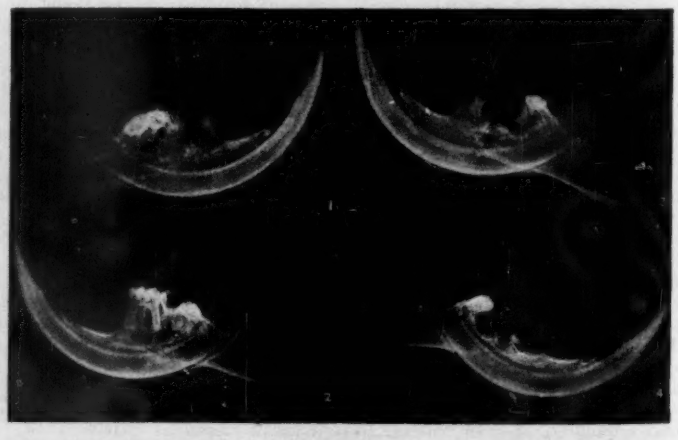
If fluorine in a concentration of 1 p.p.m. in drinking water is optimum for human consumption as now generally conceded, then it might be expected that strong tea infusions containing 20 p.p.m. of fluorine and taken in large quantities would have some abnormal effect on skeletal calcification. It is recognized that 85 per cent of fluorine in dry tea may go into an infusion; but ordinarily brews may contain only 1 p.p.m. of fluorine due to the use of only small amounts of the dried leaf. This may explain the analysis of rib bones among residents of London, England, made by Glock, Lowater and Murray[3], who found no greater concentration of fluorine than that found by similar studies in other parts of the world.

Table 1. Effect of Tea Infusion on Dental Caries of the Rat

	No. of rats	No. of carious molars	Average wt. at 23 days (gm.)	Average wt. at 135 days (gm.)	Remarks
Control	11	37	33·0	132	Moderate alveoloclasia and skeletal osteoporosis
Tea infusion (20 p.p.m. fluorine)	11	32	34·7	139	Osteoporosis and alveoloclasia similar to controls

The resemblance of dental caries in the rat to that of humans following the consumption of large quantities of tea may be only a coincidence. In order to produce good bone calcification and cariostasis in the rat, we previously found it necessary to use more than 350 p.p.m. of fluorine, optimum results being obtained with 700 p.p.m. of fluorine when given in the form of Tennessee brown rock phosphate[4]. But there are reports like that of McClure and Mitchell in which as little as 10 p.p.m. of fluorine in the diet of rats was found to have some cariostatic effect[5].

Possibly, the high calcium and phosphorus content of the fertilizer used by us influenced the action of fluorine in the cariostatic diets. In humans, toxic doses of fluorine are said to produce osteosclerosis[6]; but whether this precise effect can be observed with dietary insufficiency of calcium and phosphorus, either in experimental animals or man, has not been established. Besides considering other factors such as solubility and absorbability of fluorine from tea infusions, it will be interesting to observe whether in Great Britain the same good results with fluoridation of communal water supplies can be obtained as in the



(1) and (2). Caries and alveoloclasia in lower jaw of rat on cariogenic – water diet

(3) and (4). Similar changes in lower jaw of a litter-mate rat on cariogenic – tea infusion diet

United States without more attention to dietary calcium and phosphorus.

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Fluorine Content of some Nigerian Waters

Fluorine absorption from drinking water during the period of calcification of the teeth has long been correlated with mottling of the dental enamel[1]. In East Africa the excessive amounts of fluorine in some drinking waters have become a matter for urgent consideration[2]; but little is known of fluorine distribution in West African waters.

The surface rocks of Nigeria consist of two large areas of granites separated by marine sediments in the Niger and Benue valleys; Tertiary sediments occur in the north-east in the Lake Chad drainage basin.

On the Central Plateau, a series of Younger granites are known to have a high fluorine content which does not, except in very small amounts, break down into compounds soluble in water; fairly extensive parts of these granites are covered by basaltic lava flows of Tertiary and Recent age. Streams used for drinking-water arise by seepage from below the basalt or by drainage off purely granitic areas. Ten samples of representative Plateau waters were flown to Great Britain for examination; in nine instances the fluorine content was low—between 0·2 and 0·4 parts per million—and in one sample there was no fluorine. A mild degree of dental fluorosis was seen among members of six aboriginal tribes who lived on the Plateau.

Fluorine occurs among the minerals present in the Niger and Benue valleys. A sample of water from the shaft of a lead–zinc lode near Abakaliki contained 3·3 p.p.m. of fluorine; but surface waters in general would contain considerably less: of 65 primary schoolgirls aged seven to fifteen years examined in Niger Province, eight showed mottled dental enamel. Dental fluorosis was seen in the teeth of adults whose homes were in Adamowa, Bauchi, and Bornu Provinces. It is probable that the sources of fluorine in these areas are the crystalline rocks of the basement complex. Six samples of well water from Maiduguri town, in Bornu, had fluorine contents ranging from 0·1 to 1·2 p.p.m., and 15·8 per cent of thirty-eight girls in boarding school had a moderate degree of mottled enamel.

It is concluded that in Nigeria the fluorine compounds present in Pre-Cambrian rocks do not, except in small amounts, become soluble in drinking waters.

Samples of water were obtained for examination with the help of Dr. R. Jacobson, Mr. W. N. MacLeod and Dr. A. M. J. de Swardt, of the Geological Survey of Nigeria. Thanks are due to Prof. Margaret Murray, who undertook the examination of Nigerian waters for their fluorine content.

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Enzymic Iodination of Milk Proteins

Recently, Pitney and Russell Fraser[1] have reported studies in which they utilized, as a model system for antithyroid drug evaluation, a procedure based on that of Keston[2] for the enzymic iodination of milk proteins. This has prompted us to outline some of our observations with a similar system using purified milk enzymes and proteins. Native casein in a finely suspensible form was obtained from separated milk by differential high-speed centrifugation at 0°[3]. It was washed with water and freeze-dried from an aqueous dispersion. β-Lactoglobulin was prepared essentially according to Palmer[4]. In order to obtain lactoperoxidase (of about 40 per cent purity as judged by absorption data) the fraction of milk separating at 50–70 per cent saturation with ammonium sulphate was treated by an unpublished procedure developed by Dr. D. Morell, who also kindly provided a purified specimen of xanthine oxidase[5].

In order to test their relative reactivity in iodination experiments, the purified proteins (150 mgm.) were shaken and incubated in duplicate for 1 hr. at 37° in 0·05 *M* phosphate buffer medium at *p*H 6·8 with added xanthine (600 μgm.), iodine-131 (usually 50 μc.) with carrier potassium iodide (15 μgm.) and the two enzymes (in amounts equivalent to ten times the average contents of milk, based on the casein used), the final volume being approximately 5 ml. The precipitates obtained with 10 per cent trichloroacetic acid were washed twice with 5 per cent trichloroacetic acid, hydrolysed with 2 *N* sodium hydroxide for 16 hr. at 105°, and the hydrolysates extracted twice with equal volumes of *n*-butanol. The butanol extracts were washed twice with equal volumes of 4 *N* sodium hydroxide/5 per cent sodium carbonate. Although counts were made on the several fractions, only the radioactivity contents of the washed butanol extracts are given in Table 1 (*A*). Under these conditions, our best results indicated about 2 per cent binding of iodine in the butanol-soluble ('thyroxine') form by casein. Chromatographic fractionation of both alkaline and enzymic hydrolysates (using purified thyroid protease[6] as the enzyme) showed that more than 90 per cent of the iodine incorporated was fixed in the form 3-iodotyrosine. The addition of cupric ions and tyrosine as recommended by Weiss[7] in his iodine-uptake studies using particulate components of thyroid tissue gave no increase in the butanol-soluble fraction (Table 1,*D*).

Purified β-lactoglobulin exhibited a very weak capacity for binding iodine in butanol-soluble form.

Table 1

	A		B				C		D	
	Cas.	Lg.	Cas.$_a$	Lg.$_a$	Cas.$_b$	Lg.$_b$	Cas.	Lg.	Cas.$_1$	Cas.$_2$
Butanol extract (μC.)	4·45	2·32	2·14	0·73	1·82	0·99	2·00	1·57	4·00	4·58
After first treatment with alkali (μC.)	1·30	0·12	0·67	0·04	0·43	0·03	0·59	0·09	1·29	1·32
After second treatment with alkali (μC.)	1·03	0·03	0·52	0·015	0·37	0·01	0·46	0·03	0·82	0·81
Ratio : Cas./Lg.	34	1	35	1	37	1	15	1	—	—

A. Casein (Cas.) and lactoglobulin (Lg.) each 150 mgm., incubated 1 hr., 37°, under standard conditions and then hydrolysed (see text).

B. General conditions as in *A*, but Cas.$_a$ and Lg.$_a$ mixed prior to, and Cas.$_b$ and Lg.$_b$ subsequent to, incubation. Iodinated proteins separated by precipitation at *p*H 4·6 (Cas.), then with trichloroacetic acid (Lg.), before hydrolysis.

C. General conditions as in *A*, but with the following additions before incubation: to Lg. 5 ml. milk supernatant, from which casein was removed by high-speed centrifuging; to Cas. 5 ml. phosphate buffer.

D. General conditions as in *A*, but with addition of cupric ions and tyrosine (each $1·8 \times 10^{-4}$ *M*) to Cas.$_1$.

Even allowing for its lower tyrosine percentage composition (3·78) than casein (6·1)[6], it is much less efficient under the conditions used. In order to ascertain whether the purified casein contained, by contrast, an activator of the reaction, equal amounts of β-lactoglobulin and casein test solutions were mixed immediately before, and following, the incubation period, and the solutions then fractionally precipitated (casein at *p*H 4·6, β-lactoglobulin with trichloroacetic acid). Table 1,*B* shows that the results were comparable. To examine this point further, the supernatant of milk (5 ml.), from which the casein had been removed by prolonged high-speed centrifugation, was added to a β-lactoglobulin test solution prior to incubation. It is possible that the apparently slight favourable effect (decrease in the ratio casein to lactoglobulin) observed (Table 1,*C*) may have been due to traces of casein in the milk supernatant added.

From our overall results it seems that the tyrosine residues in β-lactoglobulin are not as favourably situated for conjugation to the iodinated thyronines as are those in casein, and that, in the iodination of milk, casein would be almost entirely responsible for the butanol-soluble fraction.

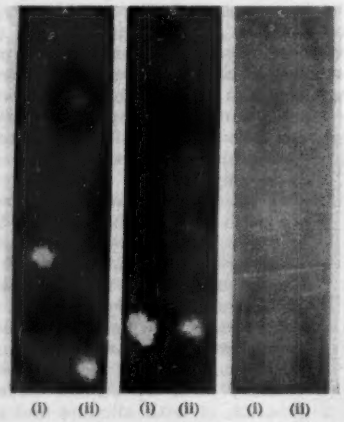

Fig. 1. Chromatograms of peroxide-treated anti-thyroid drugs. *A*. (i) Thiouracil (10^{-5} *M*) incubated for 45 min. at 37° with hydrogen peroxide (10^{-5} *M*). (ii) Thiouracil control—no peroxide added. Solvent system *n*-butanol/water.

B. (i) Thiouracil control—no xanthine added. (ii) Thiouracil (10^{-5} *M*) incubated for 45 min. at 37° with xanthine and excess xanthine oxidase and lactoperoxidase. Note trace of oxidation product at lower R_F. Solvent system *n*-butanol/water.

C. (i) Resorcinol (10^{-5} *M*) incubated for 45 min. at 37° with hydrogen peroxide (10^{-5} *M*). (ii) Resorcinol control—no peroxide added. Solvent system *n*-butanol/acetic/water

Keston[2] showed that thiourea is an effective inhibitor of the uptake of iodine by the proteins of milk, similar findings being obtained by Pitney and Russell Fraser[1] for both 2-thiouracil and resorcinol in the enzymic iodination of casein. However, the latter authors failed to prevent iodination of casein with thiouracil, in contrast to resorcinol (60 per cent inhibition), under enzyme-free conditions in which the conversion of iodide to iodine was brought about by incorporating dilute hydrogen peroxide in the medium. They therefore conclude that such anti-thyroid drugs do not act by removal of available free iodine[2]. However, the failure of thiouracil to inhibit in the 'chemical' system could be due to its greater sensitivity towards dilute peroxide than resorcinol. In fact, we have shown that thiouracil, unlike resorcinol, is completely changed by added peroxide under conditions comparable to those used by the authors mentioned, whereas it survives to a large extent when the peroxide is processed enzymically.

Solutions of thiouracil (10^{-5} *M*; 100 ml.) with and without hydrogen peroxide (10^{-3} *M*) were incubated for 45 min. at 37° and then frozen and dried in this condition. The residues were dissolved in warm *n*-butanol (saturated with water), applied to paper and run in *n*-butanol/water (16 hr.). As can be seen from the photograph of the chromatogram taken with ultra-violet light[10] the thiouracil spot has shifted as the result of peroxide treatment (Fig. 1,*A*). Spraying the paper with Chargaff's reagent (iodine and sodium azide) produced an immediate reaction with the control spot, whereas the other reacted only weakly after some minutes. Such differentiation is similar to that observed with cysteine and cystine respectively[11]. The chromatogram (*n*-butanol/acetic/water[12]; Ehrlich reagent spray[12]) obtained after resorcinol had been treated under identical conditions is illustrated in Fig. 1,*C*. The control and treated spots are comparable in appearance and position; this was also the case when the chromatogram was run in *n*-butanol/ammonia.

The effect on thiouracil of peroxide produced enzymically was tested by incubating, for 45 min. at 37°, a solution of thiouracil (10^{-5} *M*; 100 ml.) containing xanthine (4·5 mgm.) and excess lactoperoxidase and xanthine oxidase, so that the system gave a strong positive reaction with Nadi reagent. Xanthine was omitted from the control. The incubated solutions were then treated as for the chemical system. As can be seen from Fig. 1,*B*, a major proportion of the thiouracil remains unchanged under these conditions.

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Induction of Ovarian Tumours with 9 : 10-Dimethyl-1 : 2-Benzanthracene

MAMMARY carcinoma can be readily induced in certain strains of mice by treatment with 20-methylcholanthrene. In the course of experiments intended to investigate whether other members of the same group of carcinogenic hydrocarbons are also effective on the breast, an incidental finding has been made that treatment with 9 : 10-dimethyl-1 : 2-benzanthracene leads to the appearance of ovarian tumours.

Female mice of the Bonser *IF* strain were treated with 0·5 per cent 9 : 10-dimethyl-1 : 2-benzanthracene in olive oil by the technique previously described[1]. After a small pilot series to determine dosage, the first batch consisted of thirty animals, of which eight other mice survived when the first ovarian tumour was observed after 238 days; of these, one further mouse revealed a macroscopic ovarian tumour and others showed microscopical abnormalities. In a second series of twenty-nine animals, the first ovarian tumour was found at 196 days, when there were twenty-two survivors. Of these, nine were afterwards found to have macroscopic ovarian tumours, and four showed early tumours histologically. Of the total thirty-one mice 'at risk', there were therefore macroscopic tumours in eleven (35 per cent), and the total tumours found were fifteen (48 per cent).

The macroscopic tumours were 0·5–1 cm. in diameter, bright yellow in colour and sometimes hæmorrhagic. Histologically, they were all of obviously granulosa-celled origin. Apart from the tumours, all the ovaries of mice surviving to tumour age showed histological abnormalities. One of the tumours has been successfully transplanted. It retains its histological differentiation. Some at least of the tumours appear to function œstrogenically, as estimated by vaginal smears; the non-tumour-bearing animals tested have, on the other hand, been in continuous di-œstrus. Most of the animals, including all those with ovarian tumours, have also showed breast carcinomata. There is a suggestion that the average number of breasts affected is greater in the ovarian-tumour mice than in the others.

Ovarian tumours have not been obtained in *C57* black mice with 9 : 10-dimethyl-1 : 2-benzanthracene. It has been confirmed by *ad hoc* experimentation that methylcholanthrene does not give ovarian tumours in the *IF* strain, and does not lead to histological abnormalities of the extent found following dimethylbenzanthracene treatment.

Further work is in progress before the results are published in detail, but we feel justified at this stage in directing attention to what must be regarded as an important qualitative difference in the biological action of two carcinogens belonging to the same general group of cyclic hydrocarbons.

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Influence of the Thyroid upon the Survival-Rate of Guinea Pigs treated with X-Rays

IT has been shown that the lesions of the thymus induced by X-rays are restored more quickly in thyroidectomized guinea pigs than in normal animals. This supported the supposition that (to a certain extent) disorders induced by X-rays may be dependent upon the thyroid.

The influence of X-ray irradiation upon the thyroid is still under discussion[1]. This is understandable, since it can be shown that lethal irradiation does not induce any sign of thyroid stimulation in rats, whereas signs of thyroid stimulation are observed after a non-lethal dose of radiation[2].

A total of 46 male guinea pigs of average weight 200 ± 15 gm. were irradiated and divided into three groups: (1) 15 thyroidectomized animals; (2) 16 thyroidectomized animals, which received every second day injections of 6γ thyroxin per 100 gm. (this is sufficient to prevent the thymus atrophy determined by thyroid extirpation[3]); (3) 15 normal controls.

The animals were irradiated under the following conditions: one single total irradiation of 800 r., given with a Siemens–Halske apparatus, 160 kV., 10 m.amp., target distance 50 cm., field 20 cm. × 24 cm., 1 mm. copper filter. Thyroidectomized animals were irradiated fifteen days after the operation. The survival-rate of these animals is shown in Table 1.

Table 1. SURVIVAL-RATE OF GUINEA PIGS FOLLOWING A SINGLE TOTAL X-RAY IRRADIATION OF 800 R.

Days after irradiation	Survival-rate		
	Normal	Thyroid-ectomized	Thyroidectomized and injected with thyroxin (6 γ per 100 gm. and 48 hr.)
0	15	15	16
8	15	15	16
9	13	14	15
10	11	10	13
11	8	8	8
12	6	5	6
13	5	4	5
14	4	4	4
15	3	3	3
18	3	3	3
30	3	3	3

It is obvious that thyroidectomy has not shown any influence upon the resistance of guinea pigs to X-rays. The survival curve in thyroidectomized guinea pigs is almost the same as in normal animals. This was also confirmed in thyroidectomized animals injected with thyroxin in physiological amounts.

This result seems to be in contradiction to the previous observations, from which it was concluded that lesions of the thymus induced by X-rays may be to a certain extent the expression of thyroid stimulation occurring in these conditions. In spite of this, thyroid stimulation is observed after non-lethal irradiation only[1]. It seems, therefore, that there is an upper limit to thyroid stimulation. Certainly, the part played by the thyroid in disorders induced by X-rays can be considered as slight.

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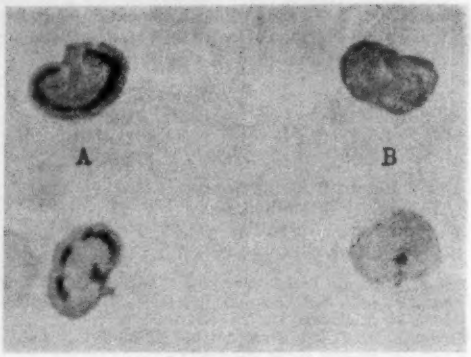
Histochemographical Effect in Rat Kidneys

In 1949, Boyd and Board[1] showed that tissue specimens placed in contact with the emulsion of a photographic plate stored in the dark affected the emulsion in such a way that images of the specimens were obtained following development and fixing. These images, due to chemical action of the specimen on the emulsion, were termed histochemographs.

Histochemographs of various tissues from normal and tumour-bearing albino rats (14 day-old transplants of dibenzanthracene sarcoma (*Rd*/3), Walker carcinoma and a 20-methylcholanthrene-induced tumour) have now been compared. The transplant animals were obtained from the University of Sheffield Field Laboratories and, in the first experiments, normal rats from the University of Sheffield Animal House were used. Blood, spleen, pancreas and liver preparations from these groups did not differ markedly; but a striking difference appeared in kidney histochemographs prepared as follows.

Rats under ether anæsthesia were sacrificed by exsanguination (aorta severed). Without delay, the kidneys were removed, sliced longitudinally and the halves blotted with Whatman No. 50 filter paper. The halves were placed (cut-side downwards) on the emulsion side of Ilford photographic paper (Contact; *C*3.1*P*; single weight; hard glossy) and the preparation mounted on a 'Pliofilm'-covered cork mat under 'Wratten Red Safelight' in a dark room. The preparation (generally kidneys from three normal and three tumour animals were compared simultaneously) was stored in a light-tight box at − 15° C. for 50 hr. Then the film was washed for 3 min. in running water to remove tissues, developed five minutes in Kodak document developer at 20° C., washed and fixed.

As illustrated by the accompanying photograph, prepared from an original histochemograph by printing on Kodak Autopositive Document Paper, kidney preparations from thirteen tumour animals each showed a marked brown crescent (*A*) in the cortex–medulla zone. This effect was absent in the kidneys of all but two of fifteen normal rats which gave more or less uniform pale grey histochemographs (*B*). However, when the kidneys of normal rats from the University Field Laboratory stock were examined, a high proportion of these were found to give the brown crescent reaction (see table). Thus the brown crescent reaction could not be attributed to the presence of a tumour as was at first supposed.



Animals	Brown crescent reaction	
	+	−
17 tumour rats (Univ. Field Lab.)	13	4
17 normal rats (Univ. Field Lab.)	14	3
15 normal rats (Univ. Animal House)	2	13

Rats from the University Field Laboratory are of the Wistar strain bred there. They are maintained on bread and milk (no water) with supplements of horse meat and cod liver oil separately every second and third day. On the other hand, rats from the University Animal House were obtained or bred from Wistar strains received from dealers. These animals were maintained on commercial rat cubes (Edinburgh Rat Cube No. 86). It has not been possible to examine completely the effect of diets on the kidney reaction; but some tumour animals maintained for several days on Diet No. 86 and water still gave the brown crescent reaction. The histochemographical effect was found in both male and female tumour and normal rats.

Perhaps we are dealing with a strain difference or with the effect of a disease prevalent in the Field Laboratory animals. Sections from kidneys which gave a positive reaction were not histologically abnormal, and no amyloid could be detected in them. The substance responsible for the brown crescent reaction appears to be susceptible to decomposition or to be readily diffusible, since kidneys which have given a positive reaction are no longer capable of producing the effect after 50 hr. exposure.

Thanks are due to Mr. O. Thornburn of the University of Sheffield Field Laboratories for supplying the tumour animals, to Dr. H. E. Harding for examining the histological preparations, and to Prof. H. N. Green for his interest. The work was supported by a grant from the British Empire Cancer Campaign.

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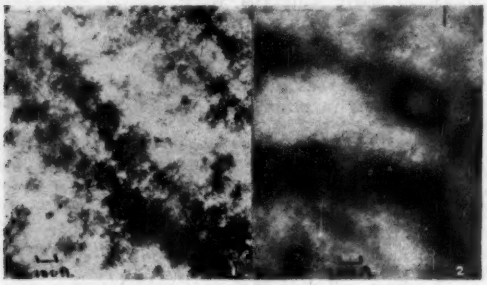
High Resolution Electron Micrographs of Thin Tissue Sections

USING a method described elsewhere[1], we have been able to cut serial sections of about 250 A. thickness, and, by varying the speed of cutting successive sections, serial sections of thickness alternately about 350 A. and 150 A. There were always thin and thick areas within individual sections. On the basis of the general rule suggested by Cosslett[2], that the optimum resolution obtainable from a section is of the order of one-tenth of the thickness, the thinner parts of the 150 A. sections should afford resolutions of 10 A. We have succeeded in obtaining such resolutions, as illustrated in Fig. 1.

The specimen is a section of a *C3H* mouse breast tumour; an intracellular 'double membrane' is clearly visible across the centre of the picture. Comparison of the detail observed with the 100 A. scale shows that resolutions of 10 A. have been obtained.

It is clearly necessary to avoid mistaking photographic grain for fine detail. For this reason, the following controls were used. First, the negatives and prints at all stages were submitted to several of the leading photographers here. All were of the opinion, without any doubt, that the detail observed did not represent photographic grain. Secondly, a negative similar so far as possible and particularly in emulsion, development, etc. (actually the next field on the same plate), to the one shown here, but electronically slightly out of focus, was put through a similar process of enlargement; sharp optical focusing was obtained by the use of a small scratch on the emulsion. In such a print no sign of detail



C3H mouse breast tumour. Intracellular 'double membrane' (1) In focus; (2) out of focus

is visible (Fig. 2), indicating that the structure shown in Fig. 1 represents neither photographic grain nor an artefact due to electron scattering in the emulsion.

While resolution of this order is thus shown to be attainable in electron micrographs of sections of animal tissues, at present it can only be attained with selected fields.

Thanks are due to Mr. J. B. Kirkham, of the Department of Experimental Pathology and Cancer Research, for the photographic enlargements.

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Fructose in the Fœtal Fluids of Deer

THE fœtal fluids of a number of species have been examined recently for the presence of free fructose[1]. This study has now been extended to the examination of the fœtal fluids of three species of deer. The fluids were obtained after pregnant does had been shot. Protein-free filtrates of the fluids were prepared by the barium–zinc method of Somogyi[2]. Total reducing substances were determined by the method of Nelson[3], and fructose by a modification of the Seliwanoff method due to Cole (as described by Bacon and Bell[4]).

Fructose was shown to be present in both the allantoic and amniotic fluids of three roe deer (*Capreolus capreolus*), one Père David's deer (*Elaphurus davidianus*) and many specimens of fallow deer (*Dama dama*). The fructose concentrations were usually within the range 100–300 mgm. per cent, and accounted for a large proportion of the total reducing substances. The concentrations of both total reducing substances and fructose were invariably higher in the allantoic than the amniotic fluid. The non-fructose reducing substances consisted mainly of glucose.

Sufficient specimens of fœtal fluids of fallow deer became available for a study of the variation of the sugar concentrations with fœtal age. Fig. 1 shows the variation of total reducing substances and of fructose in the allantoic fluids and of total reducing substances in the amniotic fluids with fœtal crown-

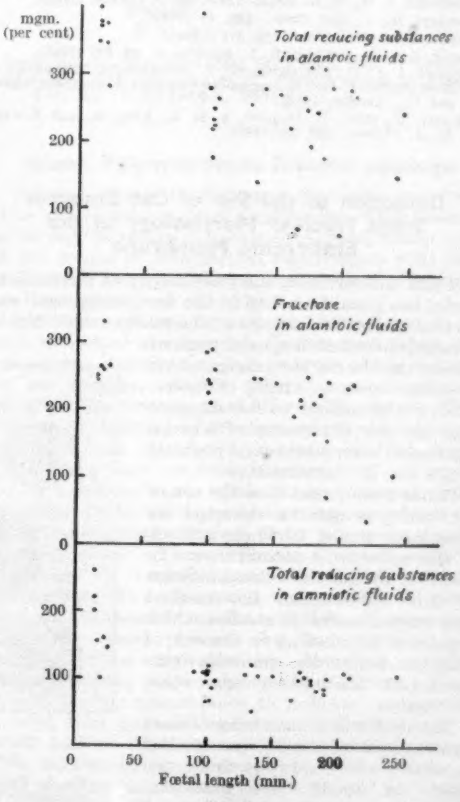

Fig. 1

rump length. Fructose is the major constituent of the amniotic total reducing substances. The fœtal ages extend over the period 30–130 days (gestation period approximately 230 days). Unfortunately, no specimens of fœtal fluids were available from near-term fœtuses.

The results lead to the following conclusions. The concentrations of both fructose and glucose in the allantoic fluid were higher than in the respective amniotic fluid. High concentrations of the sugars in both fluids occurred at a very early stage of pregnancy, and lower values were recorded as the fœtal length increased. These results must be considered together with the fact that the volumes of the fœtal fluids increase during pregnancy[5]. The results reported here show greater consistency and a somewhat different type of behaviour from those recorded on the fœtal fluids of sheep[6]. It has not been possible, as yet, to compare the composition of the fœtal fluids with that of fœtal blood.

I am grateful to Dr. R. J. Harrison, of the Department of Anatomy, who supplied the specimens of fœtal fluids, to Prof. F. L. Warren for advice, and to the Sir Halley Stewart Trustees for a grant.

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Detection of the Sex of Cat Embryos from Nuclear Morphology in the Embryonic Membrane

A sex difference in the morphology of intermitotic nuclei has been described in the nervous system[1] and various tissues and organs of the mature cat[2]. Nuclei of females contain a special mass of chromatin, the sex chromatin, which is seldom seen in nuclei of males. Evidence available so far suggests that the sex chromatin of females represents heterochromatic portions of the two *X* chromosomes.

It has been found that the sex of cat embryos can be detected by examining nuclei in whole mounts of the embryonic membranes. In addition to the theoretical interest of this observation, the method may prove useful in studies which require a decision as to the sex of embryos before the genitalia have developed distinctive sex characteristics.

The embryonic membrane (fused amnion and allantois) was studied in thirty-nine embryos from ten litters of 19–50 days gestation. The membrane was fixed in a formol – acetic – alcohol mixture for 24 hr. and in 70 per cent alcohol for a further 24 hr. Small pieces were removed from thin parts of the membrane between blood vessels, and placed in distilled water in watch-glasses. Separate pieces of embryonic membrane from each embryo were stained with Harris's hæmatoxylin and cresyl echt violet, the solutions being changed with a pipette. The stained preparations were transferred to a microscope slide, cleared with xylol, mounted in piccolyte, and studied with the oil-immersion objective.

Nineteen of the thirty-nine embryos were sufficiently mature to permit identification of sex by examination of the external genitalia; eleven were females and eight were males. The nuclei of the amnion and allantois had the following characteristics in these nineteen embryos: 96–98 per cent of the nuclei in females showed a mass of chromatin, plano-convex in shape, lying at the nuclear membrane (Fig. 1). A similar, although smaller, mass of chromatin was seen in only 7–12 per cent of nuclei in the embryonic membrane of male embryos (Fig. 2). The special mass of chromatin which is characterized by a size relation to sex is the sex chromatin, as described earlier in tissues of adult cats[2].

Twenty embryos were in an earlier stage of development, prior to differentiation of the external genitalia. Nuclei of the amnion and allantois showed a typical female morphology in eleven embryos, the sex chromatin being identified in 96–100 per cent of nuclei. The morphology of the nuclei was typically male in the other nine embryos, with a small mass which might be interpreted as sex chromatin visible in 8–9 per cent of nuclei. It is inferred that these two groups of early embryos were female and male, respectively.

Nuclear morphology within the embryo was similar to that of the embryonic membrane. A detailed account of the sex difference in the morphology of the nucleus in embryonic tissues is in preparation.

It is possible that a sex difference in the intermitotic nuclei of amnion and allantois, and in embryonic tissues generally, may occur in those animals which have a sex difference in the nuclei of mature nerve cells[3], although embryos of species other than the cat have yet to be studied from this point of view.

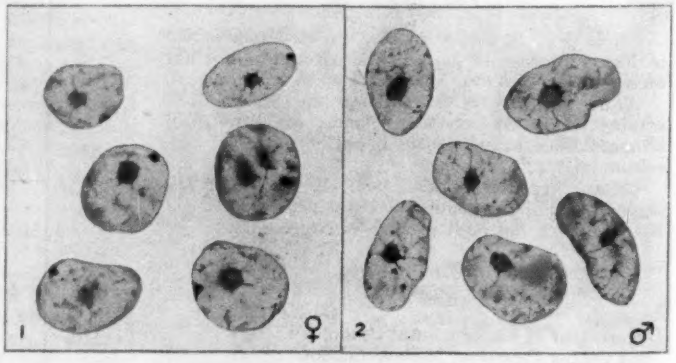

Fig. 1. Nuclei in the embryonic membrane of a female cat embryo. They contain a mass of sex chromatin which lies at the nuclear membrane in most instances

Fig. 2. Nuclei in the embryonic membrane of a male cat embryo. A chromatin mass, comparable in size, shape and position with the sex chromatin of the female, is seldom seen in male nuclei

This work was made possible by a grant-in-aid from the National Research Council of Canada.

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Oct. 6.

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Influence of Position of Truss on Pleiocotyly in Tomato

LEWIS[1] has shown that position of truss affects the manifestation of rogues in tomato. Darlington and Mather[2] believe this character is plasmagenically inherited, like other forms of rogues in inbreeding species. An investigation was therefore made to determine whether truss position and plasmagenes also influence pleiocotyly, that is, the variation in cotyledon number, in tomato (*Lycopersicon esculentum*).

Eight plants of Clucas-99 variety were used, and fruits were harvested from individual trusses. Seeds from each were sown. Fig. 1 gives the mean amount of pleiocotyly occurring in offspring from all plants plotted against truss position. This shows that there is a decrease in pleiocotyly from the first to the third truss, with a rise at the fourth. This is converse to that for roguing and truss position found by Lewis[1]. An analysis of variance shows that $P = 0{\cdot}01$ for 'trusses' and $P > 0{\cdot}20$ for 'plants'. Hence, truss position is important in effecting manifestation of pleiocotyly in the offspring; but plants do not differ significantly from one another in their effects, which is not unexpected in an inbred.

As the data strongly indicate that truss position influences pleiocotyly production, and because rogues in tomatoes are possibly plasmagenically controlled, a test was made to see whether rogues and pleiocotyly are associated. One might expect that rogues would produce more pleiocotyls than normal plants if pleiocotyly were influenced by cytoplasmic factors. Table 1 gives data from Clucas-99. A χ^2 analysis for independence gives $\chi^2 = 1{\cdot}53$ and $P > 0{\cdot}20$. Hence roguing and pleiocotyly are independent of each other; however, pleiocotyls produce twice as many rogues. This provides further evidence that cytoplasmic effects are not primarily responsible for the production of pleiocotyls, but might play some part in their activities.

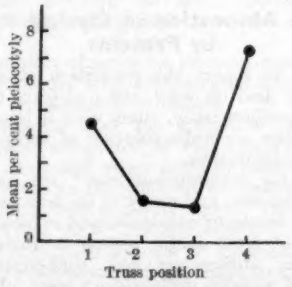

Fig. 1. Per cent pleiocotyly frequency in Clucas-99 tomato variety plotted against position of truss (lowest is 1, highest is 4). Each spot represents the mean of eight plants

Table 1. DISTRIBUTION OF PLEIOCOTYLY IN NORMAL AND ROGUE CLUCAS-99 TOMATO

Type of pleiocotyly	Normal seedlings	Rogue seedlings
Monocot.	1	0
Dicot.	27	7
Dicot.-abnormal	2	1
Pseudo-tricot.	4	1
Tricot.	9	7
Pseudo-tetracot.	2	1
Tetracot.	1	0
Total	46	17

Table 2. PLEIOCOTYLY IN STONER'S EXHIBITION TOMATO

Cross	Dicot. (per cent)	Pleiocot. (per cent)	No. of rogues
Normal selfed	100	0	0
Rogue × normal	96	4	0
Normal × rogue	93	7	1 pleiocot.

Data were also available for Stoner's Exhibition variety. Dr. D. Lewis (unpublished) has found the distribution of pleiocotyly as given in Table 2. Here again pleiocotyls were not rogues; but pleiocotyls increased in proportion following reciprocal crosses between rogues and normal. This suggests that dicotyly is a condition partly resulting from balance between chromosomes and cytoplasm. When one or other is disturbed, the threshold for dicotyly is broken down and pleiocotyly results.

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Some Polyenes from *Brassica rutabaga*

RECENT studies on fruit and vegetable processing have shown some natural constituents of the material to be very sensitive to treatments, particularly heat. In the course of dehydration experiments with roots of *Brassica rutabaga*, the pigmentation of the tissues has been examined in detail.

Extraction of the pigment was carried out in the dark by means of a low-temperature technique[1], and subsequent chromatographic analysis of the solution on an alumina column yielded several polyenes adsorbed less strongly than all-*trans*-lycopene. Their absorption spectra after repeated chromatography showed single absorption maxima in the region 420–450 mμ with no fine structure, and all except No. 5 failed to agree with known maxima either for naturally occurring poly-*cis*-compounds[2,3] or for poly-*cis*-compounds derived from the isomerization of prolycopene[4]. These differences cannot easily be explained by variations in solvent and spectrophotometer. In each case it was possible to obtain all-*trans*-lycopene from the solution of chromatographically pure pigment by isomerization with iodine[5]. These pigments are, therefore, hitherto uncharacterized poly-*cis*-lycopenes. Pigment No. 5 showed a close resemblance to poly-*cis*-lycopene IV isolated from pyracantha berries by Zechmeister[2].

We believe that these pigments should have a more distinctive numbering than that referring to their position on an adsorption column, and make the following proposal, namely, that the figure for

Absorption Maxima of some of the Pigments isolated from *Brassica rutabaga*

Development sequence on alumina column	Absorption maxima in petroleum ether : boiling point, 60–80° C.	Identity of pigment
12	Not examined	This consists of a large number of bands including all-*trans*-lycopene
11	410–20* 437 452–61*	Poly-*cis*-lycopene 37
10	Not examined	
9	Not examined	
8	434–5	Poly-*cis*-lycopene 34
7	361 379 400 424–5	ζ-Carotene
6	432 454	Poly-*cis*-lycopene 32 : 54
5	426 440–5	Poly-*cis*-lycopene 26
4	429	Poly-*cis*-lycopene 29
3	425–30* 449 477	β-Carotene
2	400–405* 418	Poly-*cis*-lycopene 18
1 yellow fluorescent	332 347·5 367 397 421	Unknown
	Maxima at 397 and 421 may be due to contamination with η-carotene	
1 white fluorescent	329 346 366	Unknown

* Regions of inflexion

the main absorption maxima in the region 400–500 mμ in petrol ether of boiling point 60–80° C., deleting the first numeral, be placed after the words poly-*cis*-lycopene. For example, the poly-*cis*-lycopene with its absorption maximum at 429 mμ would become 'poly-*cis*-lycopene 29'.

Of particular interest is pigment No. 2 with a maximum at 418 mμ. This is the shortest wavelength maximum yet recorded for any lycopene isomer, and its position does not concur with present theories for spectral displacements for *cis* bonds by which all-*cis*-lycopene would be expected[4] to have its maximum in the region of 430 mμ.

Other polyenes identified in this group of pigments were zeta-carotene, beta-carotene, and a group of yellow fluorescent compounds.

This work forms part of the programme of the Ministry of Food, Scientific Adviser's Division.

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Oct. 26.

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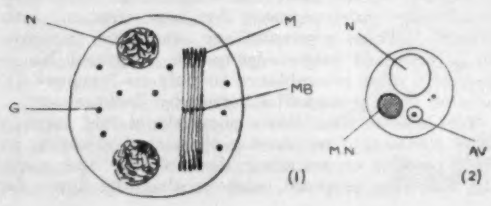
Are Spindle Fibres and Mid-body Granules Artefacts?

In consonance with the colloidal conception of protoplasm, it is generally believed that the fibres and the mid-body granules of the mitotic spindle are coagulation effects and are not an image of reality. The spindle is conceived as a fusiform area of protoplasm having high viscosity. This may be true in some cases, but we wish to record very briefly some of our observations on the living male germ cells of the grasshopper *Chrotogonus* sp. and the common house cricket *Gryllus domesticus* made under the phase-contrast microscope, after studying the spermatogenesis of these two insects by the normal laboratory technique of fixing and staining.

We have seen very clearly in the living cells not only the mitochondria, the Golgi elements, the chromosomes even in resting cells, and the acrosomal vesicle with the acrosomal granule dancing within it, but also the spindle fibres and the mid-body granules.

Out of scores of figures recording these observations, we have selected only two. Fig. 1 represents the late telophase II of *Chrotogonus* sp. The nucleus (*N*) of the secondary spermatocyte has already divided into two ; and the spindle fibres with the mid-body granules (*M.B.*) at their equator and the filamentous mitochondria (*M*) at their two poles can be very clearly made out. The Golgi elements exist at this stage in the form of vesicles (*G*) spread out uniformly in the cell. Fig. 2 represents an early spermatid of *Gryllus domesticus*. At *AV* is shown the acrosomal vesicle with its contained acrosomal granule ; at *N* is the nucleus ; and at *M.N.* lies the mitochondrial nebenkern.



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Selective Absorption of Optical Antipodes by Proteins

We wish to report the resolution of α-methoxyphenylacetic acid on wool, the (+)-form of the acid combining preferentially, when wool is immersed in a dilute aqueous alcoholic solution of the (±)-acid at the room temperature.

In previous communications[1–2] we have shown that mandelic acid and many of its derivatives carrying simple nuclear substituents, and several analogous acids derived from larger aromatic nuclei such as naphthalene, anthracene and diphenylene oxide, are resolved without difficulty on wool. In all these instances, the acids carried hydroxyl groups, and there was the possibility that the difference in the

degree of absorption of the two forms of the anion was due to a difference in the extent of the interaction of their hydroxyl groups with the protein.

Our present result shows that the occurrence of resolution is not restricted to the hydroxy acids. Indeed, the degrees of resolution of α-methoxyphenylacetic acid and mandelic acid are of the same order under the same conditions.

The α-methoxyphenylacetic acid used in our experiments was prepared by Reeve and Christoffel's method[4]; it melted at 70° (literature: m.p., 70·5–71°). Wool (30 gm.) was immersed in a solution of the (±)-acid in 500 c.c. of a mixture of equal volumes of water and alcohol, and after a time the amounts of the acid absorbed and not absorbed, and the rotations of the two fractions, were determined.

	Exp. 1	Exp. 2
Initial weight of acid in solution	7·31 gm.	7·83 gm.
Period of immersion	18 hr.	24 hr.
Weight of acid absorbed	2·54 gm.	2·45 gm.
" " " unabsorbed	4·76 gm.	5·10 gm.
Rotation of acid absorbed	+ 0·19°	+ 0·20°
" " " unabsorbed	− 0·19°	− 0·20°

The rotations were measured in a 2 dm. tube in a Hilger model, Type *M* 413, polarimeter, each of the two fractions being dissolved in 17·5 c.c. of alcohol. They are of the same order as those obtained with mandelic acid[3] in similar circumstances, and if the molecular rotations of the two acids do not differ greatly it would follow that mandelic acid and its methyl ether are resolved to almost the same degree; $[\alpha]_D$: (−)-mandelic acid, − 159·73°, in water[5]; (+)-mandelic acid, + 156·40°, in water[6]; (−)-α-methoxyphenylacetic acid, − 165·8°, in water[7]; (+)-α-methoxyphenylacetic acid, probably not optically pure, + 54°, in alcohol[8].

It is now possible to recognize some of the factors which enable the resolution of acids on proteins to be demonstrated. The protein itself must carry an adequate number of basic groups. Thus, resolution of mandelic acid has been shown to occur on wool and casein but not on silk[1,2]. The molecular rotation of the acid should be high, for the degree of separation of the optical antipodes so far observed is small. The acid should not contain groupings which favour the non-specific absorption of its anions by non-ionic forces. Thus, whereas *p*-methoxy, *p*-ethoxy, *p*-pentoxy and *p*-heptoxy mandelic acids are resolved without difficulty on wool, *p*-hexadecoxymandelic acid is not resolved at all[2]. Similarly, many acids containing azo-groups are not resolved on wool[9,10].

The resolution of acids on proteins and the extent to which it occurs is of considerable interest for the theory of biochemical processes. It has always appeared feasible that the difference in behaviour of the optical antipodes of the α-amino-acids, the α-hydroxy acids and other acids in natural processes could be related to the preferential absorption of one or other of the two enantiomorphs. Our results do not support this view; for although we have demonstrated the resolution of acids on proteins, the degree of resolution has always been small and insufficient to account for the striking differences in biochemical properties which are often observed, unless the degree of separation can be increased in natural processes, as by continued resolution at a succession of surfaces.

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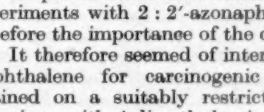
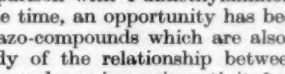
Carcinogenic Azo-compounds

In 1940, Cook *et al.*[1] reported that 2 : 2′-azonaphthalene (I) produces cancers of the liver in mice. The compound was also given to rats by subcutaneous injection, and with the food; but in this species no neoplastic changes were found in the livers. There is a brief note in the 24th Annual Report of the British Empire Cancer Campaign, 1947, p. 147, that a few small areas of cholangiectasis were observed in three out of eighteen rats receiving this compound by the oral route. No further details have been published, but Dr. A. H. M. Kirby has kindly informed us (see Kirby, Ph.D. thesis, London, 1949) that he obtained a number of foci of hepatoma in rats surviving more than 500 days. These rats were maintained on a balanced diet and were given the azonaphthalene orally. This behaviour is in marked contrast to 4-dimethylaminoazobenzene (II, X = H), which is a liver carcinogen in rats, but which is very much less active in mice. However, 4-dimethylaminoazobenzene is only effective as a liver carcinogen when tested in rats which are maintained on a diet that is low in protein and in riboflavin[2], and the original experiments with 2 : 2′-azonaphthalene were completed before the importance of the diet had been established. It therefore seemed of interest to re-test 2 : 2′-azonaphthalene for carcinogenic activity in rats maintained on a suitably restricted diet, for direct comparison with 4-dimethylaminoazobenzene. At the same time, an opportunity has been taken to test other azo-compounds which are also of interest in the study of the relationship between chemical constitution and carcinogenic activity[2].



(I)



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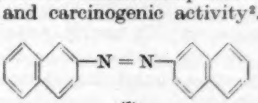

(III)

All experiments were carried out with batches of ten Wistar hooded rats, which were given food and water *ad lib.* The diet was similar to Kirby's R.D. 3 [3], except that white flour was used instead of rice starch. Control rats lost weight when maintained on this diet; but no abnormalities could be detected in the livers of animals killed after six months. To

Compound	Tumours / Survivors	Relative carcinogenic activity (ref. 3)
2 : 2′-Azonaphthalene (I)	0/9	0
1-Benzeneazonaphthalene	0/5	0
2-Benzeneazonaphthalene	0/6	0
4-Dimethylaminoazobenzene (II, X = H)	7/7 8/8	++
4 : 4′-Di(dimethylamino)azobenzene (II, X = NMe_2)	0/8	0
4′-Methoxy-4-dimethylaminoazobenzene (II, X = OMe)	4/10	+
4-Methoxyazobenzene (III, Y = OMe, X = H)	0/7	0
4 : 4′-Dimethoxyazobenzene (III, X = Y = OMe)	0/8	0

establish the effectiveness of this restricted diet, and to enable comparisons of relative carcinogenic potency to be made with other workers[4], two groups of rats were given the diet to which 4-dimethylaminoazobenzene had been added at a level of 0·06 per cent. The surviving rats were sacrificed after six months, and tumours were observed in all the livers and confirmed by histological examination (see table). Other workers have also obtained a 100 per cent incidence of liver tumours with this compound when tested under somewhat similar conditions[4].

When tested under the same conditions at the same dose-level (on a molecular weight basis), 1-phenylazonaphthalene and 2-phenylazonaphthalene proved to be inactive. 2:2′-Azonaphthalene was similarly ineffective, no abnormalities being observed in the livers of any of the surviving animals. It can only be concluded, therefore, that 2 : 2′-azonaphthalene has little or no carcinogenic activity in the rat, when tested under conditions in which 4-dimethylaminoazobenzene is a very effective carcinogen.

It has been suggested[1] that, in the liver of the mouse, 2 : 2′-azonaphthalene may be converted into 3 : 4 : 5 : 6-dibenzcarbazole, a polycyclic aromatic compound which is known to produce tumours at the site of application as well as in the liver. The present results are interesting in this connexion; but they are not inconsistent with such a view, for the absence of activity in the rat may be associated with a different metabolic pathway in this species.

Many substituted 4-dimethylaminoazobenzenes (for example, II) have already been tested for carcinogenic activity, and the results appear to be consistent with the view that activity is associated with an optimum density of electrons around the azo-linkage[2]. In agreement with the conception that there is an upper limit in electron density, 4 : 4′-di(dimethylamino)azobenzene (II, X = NMe_2) has now been shown to be entirely inactive (see table). Furthermore, 4′-methoxy-4-dimethylaminoazobenzene (II, X = OMe) was found to be moderately active, but less effective than 4-dimethylaminoazobenzene itself. All ten livers of this group showed varying degrees of diffuse fibrosis both to the naked eye and microscopically. Four of the ten showed localized white nodules varying from 4 to 10 mm. in diameter, which appeared to be neoplastic bile-duct epithelium. These areas often contained dilated cystic spaces having an angiomatous appearance. It seemed that tumours developed in the livers already showed bile-duct proliferation, the distinction between the two processes being rather subtle.

The amino-group seems to be essential for activity in this class of compound (that is, apart from azonaphthalene, which may act by a different mechanism), for 4-methoxyazobenzene and 4 : 4′-dimethoxyazobenzene (III, X = Y = OMe) were both found to be inactive.

We are indebted to Mr. H. R. Marston for the animals used in these experiments; we would also like to express our indebtedness to the University of Adelaide Anti-Cancer Committee for financial assistance.

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Aromatic Aldehydes as Specific Chromatographic Colour Reagents for Amino-Acids

Though some aromatic aldehydes have been used as amino-acid reagents[1,2], it was thought that a survey of available aromatic aldehydes would lead to the discovery of colour reactions useful in amino-acid chromatography.

The initial reaction between amino-acids and aromatic aldehydes is the formation of Schiff's bases. This, however, is only one of the possible reactions occurring. For example, hydroxyl substituted aromatic aldehydes have quininoid potentialities and thus have carbonyl activity, in addition to that of the aldehyde group itself, which may result in more complex reactions. When the reagent contains the group —CO—$(CH{=}CH)_n$—CO—, Strecker type reactions[3] may occur. Also aerial oxidation may be a further complication.

In general, the method of investigation used was as follows. The range of common amino-acids were run on one-way chromatograms, 5 μl. each of M/100 solutions being used. The sheets were dried and dipped in a 2 per cent solution of the aldehyde in acetone or *n*-butanol. The sheets were heated and observed in daylight and ultra-violet light. Benzaldehyde, cinnamic aldehyde, *p*-aminobenzaldehyde, and 2.4-dichlorbenzaldehyde give negative results; *o*-, *m*- and *p*-hydroxy-benzaldehyde give weak yellow colours with most amino-acids in daylight and ultra-violet light; ornithine and lysine give a strong yellow in the ultra-violet; 2.3- and 2.4-dihydroxybenzaldehydes give quite strong colours, but variable results occur with slight differences in heating. This is probably related to the complex reaction potentialities of the keto forms.

Vanillin gives red colours with ornithine and imino-acids when followed by 1 per cent alcoholic potash dipping[4]. The chromogenic reaction here is not a simple Schiff's condensation; for when the chromatogram is kept in an evacuated tube after alcoholic potash treatment and drying, the red colours with imino-acids do not develop. Thus aerial oxidation is probably involved. 2-Hydroxy-3-methoxy benzaldehyde gives similar results to vanillin but is rather less sensitive on the whole.

o-Phthalaldehyde has been previously used[2] as a specific reagent for glycine, histidine and tryptophan.

We dip chromatograms in a freshly prepared 0·2 per cent solution of *o*-phthalaldehyde in acetone. When the chromatograms are run in acetone – water to which 0·4 per cent urea is added, glycine gives a purple spot instead of the usual green spot. The addition of 0·2 per cent urea to the *o*-phthalaldehyde solution produces a purple colour with glycine run in other neutral solvents. Butanol – acetic acid chromatograms are unaffected by urea. Glutamic acid shows as a red-brown spot under ultra-violet light after dipping in *o*-phthalaldehyde in the presence of urea and heating. This, however, is only observed after running in neutral non-aromatic solvents showing up well on acetone/urea chromatograms. We also find *o*-phthalaldehyde gives a specific colour reaction with taurine. The fluorescence given by histidine, tryptophan and tryptamine fades on excessive heating. The colour given by histidine is yellow only when relatively large amounts of the amino-acid are present; at lower levels it is pale blue. Indole gives no colour reaction. Amino-acids not mentioned give indefinite greyish spots in the presence of urea.

The colour reactions given by *o*-phthalaldehyde are strongly affected by the solvent in which it is dissolved. Apart from the sensitivity being greater in solvents of low boiling-point and high dielectric constant, which one would expect on general considerations, sensitivity is much greater in ketonic solvents than in alcoholic ones of similar dielectric constant. We find *o*-phthalaldehyde to be particularly satisfactory in acetone solution. We also confirm that isatin[5] and ninhydrin[6] are particularly effective amino-acid reagents in acetone solution. *o*-Phthalaldehyde, isatin and ninhydrin all have the structural unit required for the Strecker degradation, though this probably only represents a part of the sequence of reactions with amino-acids. Grove[7] studied the reaction between glycine and *o*-phthalaldehyde and obtained a most complex series of products.

We find that 0·2 per cent terephthalaldehyde in acetone is a specific and sensitive reagent for histidine, tryptophan and tryptamine on paper-chromatograms. The difference between the histidine and tryptophan colours is much more clear-cut than with *o*-phthalaldehyde. While we were writing this communication, Jepson and Stevens[8] reported that the fluorescence given with ninhydrin by tryptamine was much enhanced by addition of 10 per cent acetic acid to the ninhydrin solution. We also find that when terephthalaldehyde is dissolved in 10 per cent acetic acid in acetone more intense colours are observed with tryptophan and tryptamine. This indicates that the reaction mechanism is possibly similar to that postulated by Jepson and Stevens. Under these conditions, tryptophan gives an intense blue fluorescent spot which has a yellow centre at higher concentrations. Histidine, however, gives a less sensitive colour reaction. We thus recommend the acid reagent for tryptophan and tryptamine and the neutral reagent for histidine and for differentiation between histidine and tryptophan. *iso*Phthalaldehyde gives similar results to terephthalaldehyde, but the sensitivities are lower. Comparison of results with *o*-phthalaldehyde and *iso*- and tere-phthalaldehydes indicates that the proximity of the aldehyde groups in the ortho isomer plays an important part in its reactivity towards amino-acids.

MINIMUM QUANTITIES OF AMINO-ACIDS GIVING SPECIFIC COLOURS WITH *o*- AND TERE-PHTHALALDEHYDES.
One-way 65 per cent acetone chromatograms, run 15 cm.

Reagent	Amino-acid	Conditions	Colour*	Sensitivity (μgm.)
0·2 per cent *o*-phthalaldehyde	Glycine	10 min. 50°	Green	1·0
,,	Histidine	,,	Yellow	0·5
,,	Tryptophan	,,	Yellow	1·0
,,	Taurine	10 min. 50° 1 per cent alcoholic KOH dip. 10 min. 50° then 10 min. 105°	Red	1·0
0·2 per cent *o*-phthalaldehyde in presence of urea	Glycine	10 min. 50°	Purple	1·0
,,	Glutamic acid	10 min. 105°	Red-brown	1·0
0·2 per cent terephthalaldehyde	Histidine	,,	Yellow-green	0·05
,,	Tryptophan	,,	Brown	0·20
0·2 per cent terephthalaldehyde, 10 per cent acetic acid	Tryptophan	3 min 105°	Blue	0·05
,,	Tryptamine	,,	Yellow-green	0·05

* The colours were observed in ultra-violet light of wave-length 3650 A., with the exception of those given by glycine, which were observed in daylight.

We thank Dr. J. B. Jepson, Mr. I. I. Smith and Mr. J. F. Grove for discussing this work with us, and for samples of various amino-acids and aldehydes

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Separation and Identification of Alkali Metals on Paper Chromatograms

THE alkali metals do not readily lend themselves to detection on paper chromatograms by general or specific spot reagents, except in high concentration, as, for example, using hexanitro-diphenylamine as a spray reagent for the detection of potassium. A method has been developed which utilizes the production of an insoluble coloured precipitate when potassium, cæsium, rubidium and the ammonium ion are treated with a solution of sodium cobaltinitrite. The paper chromatogram is run in the usual fashion and dried. It is then either heavily sprayed with or soaked in a solution of cobaltinitrite. The solution of Kramer and Tisdall[1] or a freshly prepared 10 per cent aqueous solution of solid sodium cobaltinitrite in 5 per cent acetic acid may be employed.

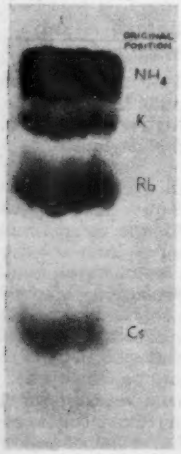
The paper is now washed in cold running water for two or three minutes in order to remove the excess of coloured reagent and reveal the 'spots' of yellow

Solvent system	R_F values			
	K	Rb	Cs	NH_4
Acetone – hydrochloric acid – water (70 : 5 : 25)	0·35	0·32	0·34	0·60
Methyl-*n*-propyl ketone – acetone – hydrochloric acid (8 : 1 : 1), ref. 3	0·04	0·04	0·04	0·10
Ethanol – hydrochloric acid – water (7 : 1 : 2)	0·17	0·16	0·17	0·46
Butanol – acetic acid – water (50 : 15 : 35), ref. 4	0·33	0·34	0·32	0·22
Benzyl alcohol – acetic acid – water (2 : 1 : 2)	0·26	0·27	0·30	0·23
Diethyl ether – nitric acid, ref. 5	0	0	0	0
Ethyl acetate – pyridine – water (2 : 1 : 2), ref. 6	0·03	0·03	0·05	0
Tetrahydrofurfuryl alcohol – water (8 : 2), ref. 7	0·63	0·62	0·62	0·59
Phenol – hydrochloric acid	0·19	0·27	0·43	0·11
m-Cresol – acetic acid – water (50 : 2 : 48), ref. 8	0·05	0·07	0·14	0
Pyridine – water (1 : 1)	0·54	0·48	0·46	0·41
Collidine – lutidine – water (1 : 1 : 2), ref. 9	0·12	0·11	0·10	0·04
Mesityl oxide – formic acid – water (1 : 1 : 2), ref. 10	0·09	0·11	0·14	0·12

cobaltinitrite of the respective ion. By this technique as little as 5 μgm. of metal has been identified. The paper is allowed to dry in the air since, when heated, some fading of the spots occurs due to decomposition of the cobaltinitrite. The spot reaction appears to be specific for this group of ions; of thirty-two other metals tested, none gave a yellow spot by this treatment. If the paper is dried by heating and then sprayed with a 0·1 per cent alcoholic solution of α-nitroso-β-naphthol made alkaline with sodium hydroxide, the spots show brown against a pale green background. An increase in sensitivity is gained by this treatment, particularly in the case of ammonium.

This technique of applying a highly coloured reagent followed by washing out excess to reveal a coloured spot has been applied by me to the use of sodium alizarin sulphonate and of quinalizarin for the detection of a wide range of metals. The immediate formation of an insoluble precipitate permits the use of aqueous solutions of the reagents, and the production of compact spots free from any spreading.

Separation of the ions potassium, rubidium, cæsium and ammonium was tested in a number of solvent systems. Chromatograms were irrigated by the ascending method[2] on Whatman No. 4 filter paper at 19° C. ± 1°. R_F values found are shown in the accompanying table.



It will be seen from the table that the only solvent among those tried which will separate all four ions is phenol. This is used equilibrated with 20 per cent (v/v) aqueous hydrochloric acid. The presence of the acid yields sharper spots than are obtained with water-saturated phenol. The accompanying photograph shows a test separation. This was carried out by the descending method using a 25-cm. solvent run. The solution containing about 50 μgm. of each metal was applied as a narrow streak along the line marked 'original position'. Irrigation was with phenol – hydrochloric acid solvent; the spots were made visible by Kramer and Tisdall's reagent and photographed through a blue filter.

In practice, a solution may be applied directly for analysis, or a preliminary concentration and purification carried out by precipitation as cobaltinitrite followed by treatment with hydrochloric acid, evaporation to dryness and solution in water. The cobalt now present in solution runs to R_F 0·09 in phenol and has been shown not to modify the flow or separation of the alkali metals.

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Mixed Crystals of Ice and Ammonium Fluoride

The "inability of forming solid solutions with any compound" was attributed to water two years ago by Mironov and Bergman[1], who refuted previous reports by Giguere and Maass[2] and by Kubaschewski and Weber[3] of the solubility of hydrogen peroxide in ice. Yet Kathleen Lonsdale[4] directed attention to the fact that ice and ammonium fluoride are not only isomorphous but also give very similar diffuse star-shaped streaks on Laue X-ray patterns, which were attributed to thermal vibrations of hydrogen nuclei. This great similarity suggested that ice and ammonium fluoride might form mixed crystals.

We have therefore examined the solubility of ammonium fluoride in ice, and we obtained positive results by the following independent methods:

(1) Single crystals of ice frozen from solutions of 0·2 per cent ammonium fluoride gave invariably positive reactions for the ammonium ion when tested with Nessler's reagent, whereas crystals frozen under similar conditions from solutions of 0·1 per cent ammonia gave negative tests.

(2) Heating curves for finely powdered ice – ammonium fluoride mixtures showed different thawing temperatures for different concentrations of the latter. These are shown by the circles in Fig. 1.

(3) Dilatometric measurements on ice containing 0·7 per cent ammonium fluoride showed a sudden negative coefficient of thermal expansion at − 4° C. which indicated incipient thawing. This is represented by a square in Fig. 1.

(4) Thermodynamic estimates of the solidus curve from data for the liquidus curve previously reported by V. C. Iamlov and E. M. Poliakova[5] using the modified Clausius–Clapeyron relation:

$$\ln\left(\frac{\text{conc. water in liquid phase}}{\text{conc. water in solid phase}}\right) = \frac{-\text{ heat of fusion of ice}}{RT} + \text{constant}$$

agree well with the experimental values. The calculated values are represented by crosses in Fig. 1.

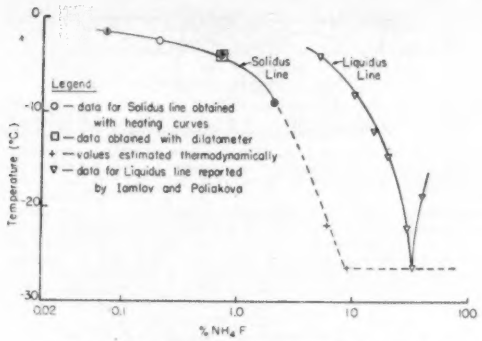

Fig. 1. Phase diagram for the system H_2O—NH_4F

(5) We have confirmed the observation of Workman and Reynolds[6] that the resistivity of ice frozen from solutions of ammonium fluoride increases with the concentration of the latter. On the other hand, substances not forming solid solutions of ice, for example, ammonium chloride, caused an enormous decrease of resistivity with increasing concentration (from approximately 2×10^{11} ohm-cm. for pure ice to about 7×10^{6} ohm-cm. for $0{\cdot}05\,N$ ammonium chloride at $-78{\cdot}5°$ C.).

(6) Finally, measurements of the dielectric constant of ice – ammonium fluoride at $-78{\cdot}5°$ C. showed a large decrease in the dielectric relaxation time with the concentration of ammonium fluoride within the range of 10^{-4} to 0·1 per cent fluoride, followed by an increase for concentrations greater than 0·1 per cent. Such an effect would not be expected of eutectic mixtures.

These results prove the formation of mixed crystals between ice and ammonium fluoride in a limited range up to about 10 per cent fluoride.

More details about the above-mentioned experiments, as well as results of further work, will be given later. These investigations were carried out under contract No. *DA*-21-018-eng-500 of the U.S. Army Engineering Corps, Snow, Ice and Permafrost Establishment.

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Conductivity induced in Insulating Materials by X-Rays

Measurements of the conductivity induced in insulating materials by X- and γ-rays have shown the existence of a long period decay[1], and more recent investigations[2-4] have shown that the electron-trapping mechanisms which apply to photoconductivity also apply to these materials. This general picture may enable the energy-level distribution of the material to be elucidated. The present experiments have been concerned with polythene and 'Perspex', and have used a d.c. amplifier to measure the current induced by X-rays of 220 kV_p (half-value layer = 2·5 mm. copper) both during and after irradiation.

The equilibrium induced current i in polythene is found to be related to the dose-rate R by the relationship:

$$i \propto R^{0{\cdot}8 \pm 0{\cdot}05} \qquad (1)$$

over the range $R = 0{\cdot}05$–20 r./min. and between 20° and 80° C. This is in agreement with the work of Mayburg and Lawrence[5], who have reported the exponent in the above equation to be $\frac{3}{4}$. This value has been confirmed by Coleman[6]. It is not necessary to assume an ionic conductivity in order to explain either the value of this exponent or the variation of induced current with temperature.

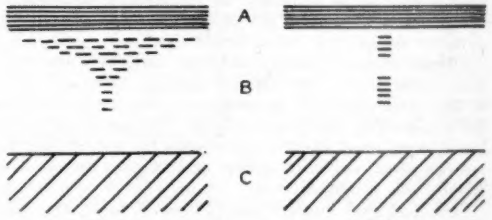

Fig. 1 Fig. 2

Distribution of electron traps in energy for polythene (Fig. 1) and 'Perspex' (Fig. 2): (*A*) conduction levels; (*B*) normally forbidden levels, with traps shown; (*C*) full levels

If the models of electron trapping suggested by Randall and Wilkins[7] and by Rose[8] can be applied to these materials, we are led to suggest that the distribution of electron traps below the conduction band in the case of polythene is exponential (Fig. 1). Further evidence in favour of this model for polythene is derived from the dependence on temperature and dose-rate of the decay of induced current: the time constant is long, varies slowly with temperature, and decreases with increasing dose-rate. This latter variation is reciprocal for low temperatures and dose-rates, but is proportional to $1/\sqrt{R}$ for higher values of i. The decaying conductivity is inversely proportional to time after about 10 min.; the deeper traps may therefore be distributed more uniformly in depth than the shallow ones.

Rose[8] gives the variation of equilibrium photocurrent with dose-rate and temperature for such a model as:

$$i \propto RN^{T/(T+T_1)}, \qquad (2)$$

where N is number of energy-levels in the lower part of the conduction band "a few kT" wide, T is temperature of the material, and T_1 is an arbitrary temperature, which, however, may have some physical significance in terms of the molecular structure of the specimen.

For $T_1 = 1{,}200°$ K., the exponent in equation (1) is 0·8. The expression leads to an increase of induced current with temperature by a factor of about ten per 100° C. near room temperature, and agrees reasonably well with the variation already observed by us[3] ($W = 0{\cdot}42$ eV.), and with the value of $W = 0{\cdot}3$ eV. obtained by Coleman[6]. Our subsequent measurements lead us to believe that the value is between these figures, probably $W = 0{\cdot}35$ eV., and we feel that the agreement is becoming more satisfactory.

It is worth noting that the value of W in the relation:

$$\sigma = \sigma_0 \exp(-W/kT)$$

has been determined by Ramsey[4] for previously irradiated polythene with no incident radiation during the measurement. He found a value $W = 1{\cdot}45$ eV.,

in close agreement with the value $W = 1{\cdot}5$ eV. reported by us[2].

Ramsey found that a new specimen of polythene, prior to any irradiation, gave $W = 0{\cdot}5$ eV. It is likely that comparatively small doses of X-radiation (10^3–10^4 r.) will create new traps in the material at deep energy-levels. We have found a similar increase of activation energy in 'Perspex' from 0·5 eV. before irradiation to 1·2 eV. after less than 10^4 r. The new activation energy does not appear to decrease with time; indeed, measurements on the decay of the conductivity induced in the insulator of small cylindrical condensers by successive weekly doses of 10^4 r. suggest that such changes are not only permanent but also cumulative. Coleman and Bohm observed a similar effect in polystyrene under continuous long-term beta irradiation[9].

Measurements similar to those described above for polythene have been carried out on 'Perspex', using a thin disk placed in a vacuum vessel with provision for controlling the temperature. Sheets of polythene have been used in this apparatus for confirming the results obtained with a flat coil of polythene cable, which are given above.

The induced current for 'Perspex' is of the same order as for polythene at 20° C., but the decay is more rapid by a factor of about ten. The dependence of induced current on dose-rate in 'Perspex' is given by:

$$i \propto R$$

over the range 0·5–30 r./min., and between 20° and 90° C. The induced current, moreover, is independent of temperature over these ranges. The time constant decreases with increasing dose-rate. These results suggest that in 'Perspex' the traps are distributed uniformly in depth[7,8], with a gap between the deep and the shallow traps (Fig. 2).

More detailed analysis of the growth and decay curves will, it is hoped, yield quantitative information on the distribution of energy-levels in these materials.

J. F. Fowler
F. T. Farmer

Royal Victoria Infirmary,
Newcastle upon Tyne. Nov. 2.

[1] Farmer, F. T., *Nature*, **150**, 521 (1942).
[2] Kallmann, H., and Kramer, B., *Phys. Rev.*, **87**, 91 (1952).
[3] Fowler, J. F., and Farmer, F. T., *Nature*, **171**, 1020 (1953).
[4] Ramsey, N. W., *Nature*, **172**, 214 (1953).
[5] Mayburg, S., and Lawrence, W. L., *J. App. Phys.*, **23**, 1006 (1952).
[6] Coleman, J. H. (private communication).
[7] Randall, J. T., and Wilkins, M. H. F., *Proc. Roy. Soc.*, A, **184**, 390 (1945).
[8] Rose, A., *R.C.A. Review*, **12**, 362 (1951).
[9] Coleman, J. H., and Bohm, D., *J. App. Phys.*, **24**, 497 (1953).

Possible Relation between Deoxyribonucleic Acid and Protein Structures

In a communication in *Nature* of May 30, p. 964, J. D. Watson and F. H. C. Crick showed that the molecule of deoxyribonucleic acid, which can be considered as a chromosome fibre, consists of two parallel chains formed by only four different kinds of nucleotides. These are either (1) adenine, or (2) thymine, or (3) guanine, or (4) cytosine with sugar and phosphate molecules attached to them. Thus the hereditary properties of any given organism could be characterized by a long number written in a four-digital system. On the other hand, the enzymes (proteins), the composition of which must be completely determined by the deoxyribonucleic acid

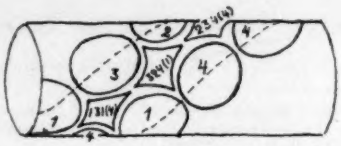

Fig. 1

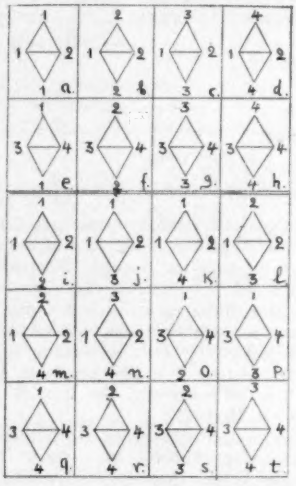

Fig. 2

molecule, are long peptide chains formed by about twenty different kinds of amino-acids, and can be considered as long 'words' based on a 20-letter alphabet. Thus the question arises about the way in which four-digital numbers can be translated into such 'words'.

It seems to me that such translation procedure can be easily established by considering the 'key-and-lock' relation between various amino-acids, and the rhomb-shaped 'holes' formed by various nucleotides in the deoxyribonucleic acid chain. Fig. 1 shows schematically the structure of the deoxyribonucleic acid molecule as derived by Watson and Crick. We see that each 'hole' is defined by only three of the four nucleotides forming it since, indeed, two nucleotides located across the axis of the cylinder are related by $1 \longleftrightarrow 2$ and $3 \longleftrightarrow 4$ binding conditions. It can easily be seen that there are twenty different types of such 'holes', as shown in Fig. 2. The first eight of them are simple, while each of the remaining twelve can exist either in right-handed or left-handed modification. It is inviting to associate these 'holes' with twenty different amino-acids essential for living organisms.

One can speculate that free amino-acids from the surrounding medium get caught into the 'holes' of deoxyribonucleic acid molecules, and thus unite into the corresponding peptide chains. If this is true, there must exist a partial correlation between the neighbouring amino-acids in protein molecules, since the neighbouring holes have two common nucleotides. There must also exist a correlation between adenine-to-guanine ratios in different organisms, and the relative amount of various amino-acids in the corresponding proteins. The detailed account of the proposed theory will appear in *Kong. Dan. Vid. Selsk.*

G. Gamow

George Washington University,
Washington, D.C. Oct. 22.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, February 15

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY (at the University, Manchester), at 5.45 p.m.—Prof. A. C. B. Lovell: "Manchester's Great Radio Telescope" (Percival Lecture).

INSTITUTE OF METAL FINISHING, LONDON BRANCH (in Room 153, Connaught Building, Northampton Polytechnic, St. John's Street, London, E.C.1), at 6 p.m.—Discussion on "Technical Education—How it can Help You".

INSTITUTION OF ELECTRICAL ENGINEERS, EDUCATION DISCUSSION CIRCLE (at Savoy Place, London, W.C.2), at 6 p.m.—Discussion on "The Teaching of the Subject of Insulating Materials".

SOCIETY OF CHEMICAL INDUSTRY, MICROBIOLOGY GROUP (in the Hall of the Institution of Structural Engineers, 11 Upper Belgrave Street, London, S.W.1), at 6.15 p.m.—Dr. N. J. Berridge: "Inhibitory Substances of Bacterial and Other Origins in Milk and Milk Products".

Tuesday, February 16

BRITISH PSYCHOLOGICAL SOCIETY, INDUSTRIAL SECTION (in Room 105, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 1 p.m.—Mr. J. G. W. Davies: "Vocational Guidance in the Universities".

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. J. L. Watling: "Is it Possible for Us to Know the Future ?"*

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS (at the Institution of Electrical Engineers, Savoy Place, London, W.C.2), at 2.15 p.m.—Mr. G. Henderson: "Mechanization of Bracken Eradication".*

SOCIETY OF CHEMICAL INDUSTRY, AGRICULTURE GROUP (in the Chemistry Lecture Theatre, Royal College of Science, Imperial Institute Road, London, S.W.7), at 2.30 p.m.—Dr. K. L. Robinson: "Antibiotics in Animal Feeding".

EUGENICS SOCIETY (at Manson House, 26 Portland Place, London, W.1), at 5 p.m.—Prof. F. A. E. Crew, F.R.S.: "A Eugenic Appraisal of the Welfare State"* (Galton Lecture).

BRITISH POSTGRADUATE MEDICAL FEDERATION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Sir Neil Hamilton Fairley, F.R.S.: "Anti-malarial Drugs—Their Action in Different Stages of the Malaria Parasite in Man".* (Tenth of fifteen Lectures on "The Scientific Basis of Medicine".)

INSTITUTION OF ELECTRICAL ENGINEERS (at Central Hall, Westminster, London, S.W.1), at 6 p.m.—Mr. O. W. Humphreys: "Electro-Heat and Prosperity" (Faraday Lecture).

Wednesday, February 17

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Mr. R. W. Marsh: "Modern Developments in Fungicide Research" (Fernhurst Lecture).

PHYSICAL SOCIETY, COLOUR GROUP (in the Physics Department, Imperial College, Imperial Institute Road, South Kensington, London, S.W.7.), at 3.30 p.m.—Dr. L. C. Thomson: "A Study of the Appearance of Spectral Colours and their Relationship to Müller's Theory of Vision"; Prof. W. D. Wright: "Some Conservative Thoughts on the Trichromatic Theory".

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Scientific Papers.*

ROYAL MICROSCOPICAL SOCIETY (at Tavistock House South, Tavistock Square, London, W.C.1), at 5.30 p.m.—Dr. R. G. White: "Microscopy of Antigens and Antibodies Within Tissues by the Use of Fluorescent Antibody".

BRITISH INSTITUTION OF RADIO ENGINEERS, LONDON SECTION (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Mr. W. D. Kemp and Mr. B. R. Greenhead: "Electronics in Film Making".

OVERSEAS SCIENCE STUDENTS ASSOCIATION (at the Society for Visiting Scientists Ltd., 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Prof. H. Dingle: "The Origin and Nature of Science".

Thursday, February 18

ASSOCIATION FOR THE STUDY OF ANIMAL BEHAVIOUR (at Birkbeck College, Malet Street, London, W.C.1), at 10.45 a.m.—Symposium on "Behaviour and the Nervous System".

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. H. P. Broida and Mr. A. G. Gaydon: "The Herzberg Bands of O_2 in an Oxygen Afterglow and in the Night Sky Spectrum"; Mr. J. M. Groocock and Mr. F. C. Tompkins: "The Decomposition of Solid Azides by Electron Bombardment".

INSTITUTION OF MINING AND METALLURGY (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. W. E. Sinclair: "Production of Asbestos in South Africa".

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. A. Zygmund: "On the Interpolation of Linear Operations".

PHYSICAL SOCIETY, ACOUSTICS GROUP (joint meeting with the INSTITUTE OF METALS, at 4 Grosvenor Gardens, London, S.W.1), at 5.15 p.m.—Scientific Papers.

PHYSICAL SOCIETY, LOW TEMPERATURE GROUP (in the Lecture Theatre of the Science Museum, South Kensington, London, S.W.7), at 5.30 p.m.—Report on the recent Congress of the International Union of Physics at Houston, U.S.A.

SOCIETY OF CHEMICAL INDUSTRY, ROAD AND BUILDING MATERIALS GROUP (joint meeting with the CORROSION GROUP, at the Institution of Structural Engineers, 11 Upper Belgrave Street, London, S.W.1), at 6 p.m.—Mr. Hector Campbell: "The Use of Non-Ferrous Metals in Domestic Water Supply".

ROYAL AERONAUTICAL SOCIETY (joint lecture with the HELICOPTER ASSOCIATION, at 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. F. J. O'Hara: "Helicopter Research".

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Scientific Papers.

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Dr. M. G. P. Stoker and Dr. B. P. Marmion: "The Clinical Picture and Epidemiology of Q Fever".

Friday, February 19

INSTITUTION OF MECHANICAL ENGINEERS (joint meeting with the INDUSTRIAL ADMINISTRATION AND ENGINEERING PRODUCTION GROUP, at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Mr. L. H. Leedham: "The Impact of Development and Research on Production and Design".

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. W. S. Feldberg: "On Some Physiological Aspects of Histamine".*

SOCIETY OF CHEMICAL INDUSTRY, FINE CHEMICALS GROUP (in the Chemistry Lecture Theatre, King's College, Strand, London, W.C.2), at 7 p.m.—Scientific Papers.

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. Karl T. Compton (U.S.A.): "High Voltage for Cancer Therapy and Food Sterilization".

Saturday, February 20

BIOCHEMICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 11 a.m.—Symposium on "The Chemical Pathology of Animal Pigments".

BRITISH PSYCHOLOGICAL SOCIETY (in the Psychology Department, University College, Gower Street, London, W.C.1), at 2.30 p.m.—Dr. Hannah Steinberg: "Experiments on Psychological Effects of Drugs".

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Mr. W. Watson: "Ancient Chinese Civilization".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ANALYST (including micro-analyst) (with an honours degree or equivalent qualification) IN THE CHEMISTRY DEPARTMENT—The Secretary, The University, Aberdeen (February 17).

ASSISTANT EXPERIMENTAL OFFICER or EXPERIMENTAL OFFICER (preferably with a degree in botany or agricultural botany) at the Agricultural Research Council's Unit of Experimental Agronomy, Oxford, for field investigations connected with the development of herbicides and arboricides for vegetation control—The Secretary, Agricultural Research Council, Cunard Building, 15 Regent Street, London, S.W.1 (February 17).

HEAD OF THE DEPARTMENT OF CHEMISTRY—The Registrar, College of Technology, Suffolk Street, Birmingham (February 19).

ANALYST, Experimental Officer grade (with a recognized qualification in chemistry, and preferably with experience of analysis of soils and plants) IN THE NUTRITION OF FRUIT PLANTS SECTION at the Long Ashton Research Station (University of Bristol)—The Secretary, Research Station, Long Ashton, Bristol (February 20).

ASSISTANT EXPERIMENTAL OFFICER (graduate, preferably with some previous experience in bacteriological work) IN THE BACTERIOLOGY DEPARTMENT, to take part in research on the intestinal flora of the pig—The Secretary, National Institute for Research in Dairying, Shinfield, near Reading, quoting 54/1 (February 20).

BIOCHEMIST (honours science graduate) for research duties in the Geriatric Department of the Sunderland Hospital Group—The Senior Administrative Medical Officer, Newcastle Regional Hospital Board, "Blythswood South", Osborne Road, Newcastle-upon-Tyne 2 (February 20).

ENGINEERS AND PHYSICISTS (with first- or second-class honours degree in physics or engineering) IN THE ELECTRONICS DIVISION, for work ranging from fundamental research of circuitry and the physics of nuclear radiation detectors to devising and developing electronic devices for the Atomic Energy Project—The Establishment Officer, Atomic Energy Research Establishment, Harwell (February 20).

HEAD OF SCIENCE DEPARTMENT—The Education Officer, Bournemouth Municipal College of Technology and Commerce, Bournemouth (February 20).

ANALYTICAL CHEMIST, Assistant Lecturer grade, IN THE DEPARTMENT OF AGRICULTURAL CHEMISTRY—The Registrar, Wye College, near Ashford, Kent (February 22).

CHEMIST (with some knowledge of bacteriology, biochemistry, or the chemistry of soils or sewage) with the British Electricity Authority, to study the effects on rivers of power station operations—The Director of Establishments, British Electricity Authority, Winsley Street, London, W.1, quoting T/449 (February 22).

BIOCHEMIST, Scientific Officer grade, in the Cider and Fruit Juices Section, at the Long Ashton Research Station, Bristol (University of Bristol)—The Registrar and Secretary, The University, Bristol (February 27).

HEAD OF THE PHARMACY DEPARTMENT—The Principal, Brighton Technical College, Brighton 7 (February 27).

GRADUATE (with first- or second-class honours in geology and training in mineralogy and crystallography) IN THE DEPARTMENT OF PEDOLOGY, X-RAY SECTION—The Secretary, Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen (February 28).